Government of Canada / Gouvernement du Canada
Canadian Forestry Service / Service canadien des forêts

Development of biomass equations for British Columbia tree species

J.T. Standish, G.H. Manning and J.P. Demaerschalk

Information Report BC-X-264
Pacific Forest Research Centre

Énergie de la Forêt
Energy from the Forest
Energy from the Forest
Energy from the Forest

85-5475/

Development of Biomass Equations for British Columbia Tree Species

by

J.T. Standish*
G.H. Manning**
&
J.P. Demaerschalk***

* Talisman Land Resource Consultants
300-842 Thurlow St.
Vancouver, B.C. V6E 1W2

** Pacific Forest Research Centre
506 W. Burnside Rd.
Victoria, B.C. V8Z 1M5

*** Faculty of Forestry
University of British Columbia
Vancouver, B.C. V6T 1W5

Canadian Forestry Service
Pacific Forest Research Centre

BC-X-264

1985

Canadian Forestry Service
Pacific Forest Research Centre
506 West Burnside Road
Victoria, B.C.
V8Z 1M5

© Minister of Supply & Services Canada, 1985
ISSN 0705-3274
ISBN 0-662-14013-3
Cat. No. Fo46-17/264E

Foreword

ENFOR is the acronym for the Canadian Government's ENergy from the FORest (ENergie de la FORêt) program of research and development aimed at securing the knowledge and technical competence to facilitate in the medium to long term a greatly increased contribution from forest biomass to our nation's primary energy production. This program is part of a much larger federal government initiative to promote the development and use of renewable energy as a means of reducing dependence on petroleum and other non-renewable energy sources.

The Canadian Forestry Service (CFS) administers the ENFOR Biomass Production program component which deals with such forest-oriented subjects as inventory, harvesting technology, silviculture and environmental impacts. (The other component, Biomass Conversion, deals with the technology of converting biomass to energy or fuels, and is administered by the Renewable Energy Branch of the Department of Energy, Mines and Resources). Most Biomass Production projects, although developed by CFS scientists in the light of ENFOR program objectives, are carried out under contract by forestry consultants and research specialists. Contractors are selected in accordance with science procurement tendering procedures of the Department of Supply and Services. For further information on the ENFOR Biomass Production program, contact...

ENFOR Secretariat
Canadian Forestry Service
Ottawa, Ontario
K1A 1G5

This report is based on ENFOR project P-142 which was carried out under contract by Talisman Land Resource Consultants, Vancouver, B.C. (DSS File No. 07SB.KL017-9-0655).

Résumé

Des équations de masse ont été établies pour 1 155 arbres, de 22 essences commerciales, répartis dans toute la Colombie-Britannique, sauf dans la partie nord et les îles de la Reine-Charlotte. Les arbres ont été échantillonnés suivant une méthode destructive, et des équationde la forme $y = b_0 + b_1D^2H$, ainsi que des équations linéaires multiples basées sur D, H et V et leurs interactions, ont été construites. Les deux types d'équations donnent des estimations d'une précision et d'une exactitude raisonnable, et le choix de l'une ou l'autre dépend de l'application que l'on veut faire des équations de masse.

Abstract

Biomass equations were developed for 22 commercial species covering all of B.C. except the northern part of the province and the Queen Charlotte Islands, based on 1155 sample trees. Trees were destructively sampled and equations of the form $y = b_0 + b_1D^2H$ and multiple linear equations based on D, H and V and their interactions were developed. Both forms of equation give reasonably accurate and precise predictions, and choice depends on the use to which the biomass equations will be put.

Contents

	Page
Foreword	3
Abstract	4
Introduction	6
Methods	6
Sample Allocation and Sample Tree Selection	6
Tree Sampling Procedures	7
Other Data Collected	7
Laboratory Processing	9
Data Processing	9
Regression Analysis	9
Results and Discussion	10
Comparison of Various Prediction Models and Use of V as an Independent Variable	10
The Contribution of V as an Independent Variable	12
Final Regression Analysis	13
Additivity of Coefficients	16
Precision	17
Accuracy	17
Degeneracy	17
Extrapolation	17
Time-Related Variability	17
Literature Cited	18
Appendix A	42
Appendix B	44
Appendix C	45
Appendix D	48

Introduction

Love (1980) has indicated the potentially great contribution of forest biomass to Canada's future energy supply. In British Columbia logging residue has been identified as a potentially viable energy source (McDaniels 1981). However, a prerequisite to realizing this potential is the availability of an adequate forest biomass inventory (Bonner 1979; Dobbs 1981).

Many studies attempting to estimate biomass of British Columbia tree species have been conducted (Stanek and State 1978) but in most cases their scope has been local rather than regional. Tree components have been defined in various ways for different studies, and various prediction equation models and units for coefficients (Imperial *vs* metric) have been used.

The objective of the study on which this paper is based was to develop a generalized set of equations which can be used in conjunction with the existing provincial forest inventory to estimate the quantity of forest biomass available in British Columbia. More specifically, the objective was to develop whole-tree and tree component biomass relationships for 22 native tree species and varieties (Appendix D), applicable to second-growth stands.

The regression equations were to be applicable, at least as a first approximation, on a regional basis. Independent variables were to be restricted to those conventionally measured in forest inventories, namely diameter at breast height, outside bark (Dbh) and height; and tree component relationships were to be conducive to simple mathematical summation, as discussed by Evert and Alemdag (1979) and Kozak (1970). Although Dbh and height were the only measured variables used in developing the regression equations, other tree, stand and site information was collected for each sample tree in order to provide a data base for future analyses.

Methods

Sample Allocation and Sample Tree Selection

The initial allocation of samples to tree species was proportional to the provincial volume inventory, but was later modified so that each tree species had forty or more sample trees in order to produce biomass relationships of the same order of significance and confidence for each species. Ideally, sample allocation would have consisted of an equal number of randomly-selected observations of biomass over the range of interest for each fixed value of the independent variables (Demaerschalk and Kozak 1974). Furthermore, samples should have reflected a wide range of stand and site conditions and geographic variability so that the prediction equations would be applicable on a broad regional or provincial scale (Cunia 1979). However, technically rigorous sample tree selection and optimal sample allocation schemes, as discussed by Demaerschalk and Kozak and Cunia (1979), were not practicable due to budgetary constraints.

Given the constraints, a more pragmatic approach was adopted as follows:

1) A target number of sample trees was designated for each species.

2) Provincial volume inventory data were examined to determine a range of Dbh and height classes for each species.

3) Sample trees were allocated equally to each Dbh and height class within species.

4) Where extra samples remained following equal allocation to each class, the remaining samples were allocated to the extreme classes.

5) The number of trees in each size class for a species were then allocated to various geographic areas.

6) As sampling progressed, the number of trees allocated to a size class for a species was, when necessary, reallocated, using the same general approach as noted above, to reflect the range of tree size actually occurring in accessible stands.

Geographic sampling areas were defined mainly by administrative boundaries and access. Because of high costs, no sampling was conducted on the Queen Charlotte Islands, in the north coastal region, in the Peace River region or in the northwestern part of the province north of Highway 16. Another ENFOR biomass inventory project in the Yukon Territory provides data applicable to some of northern British Columbia (Massie 1983).

Additional sampling restrictions were that sample trees were to be in the codominant crown class, forked trees were avoided except in some deliquescent hardwoods, and trees with dead or broken tops were avoided. Open-growing or wolf trees which are not representative of a common growth habit for a species were avoided and trees with decay indicators and trees infested with bark beetles or defoliating insects were also avoided. It was necessary to include some sample trees in the intermediate crown class for shade-tolerant species, so that smaller diameter classes were adequately represented.

Tree Sampling Procedures

Standards and procedures for sampling individual trees are given in Appendix C and closely follow those presented by Alemdag (1980). The biomass components defined for this study are shown in Figure 1. They include bole wood and bark from ground level to a 2.5-cm bole diameter, three live branch size classes, and dead branches and foliage. Cones were included with their appropriate branch size class for fresh mass determinations but were excluded for oven-dry mass. Only fresh mass was determined for dead branches. Underground biomass was not sampled.

Trees were cut at a point 30 cm above the point of germination, then limbed and bucked at intervals of 2m or less. The total fresh mass of the bole and crown components was determined directly by weighing in the field, except for large bole sections. These were measured for inside and outside bark volume, and mass was later calculated by applying mass-to-volume ratios determined from sample discs. The above-ground mass of the stump was determined in a similar manner. Volume of stem sections was calculated by the Smalian formula; volume calculation assumed a cylindrical shape for stumps. Sample discs were taken from each stem section to determine the ratios of fresh and oven-dry wood and bark mass.

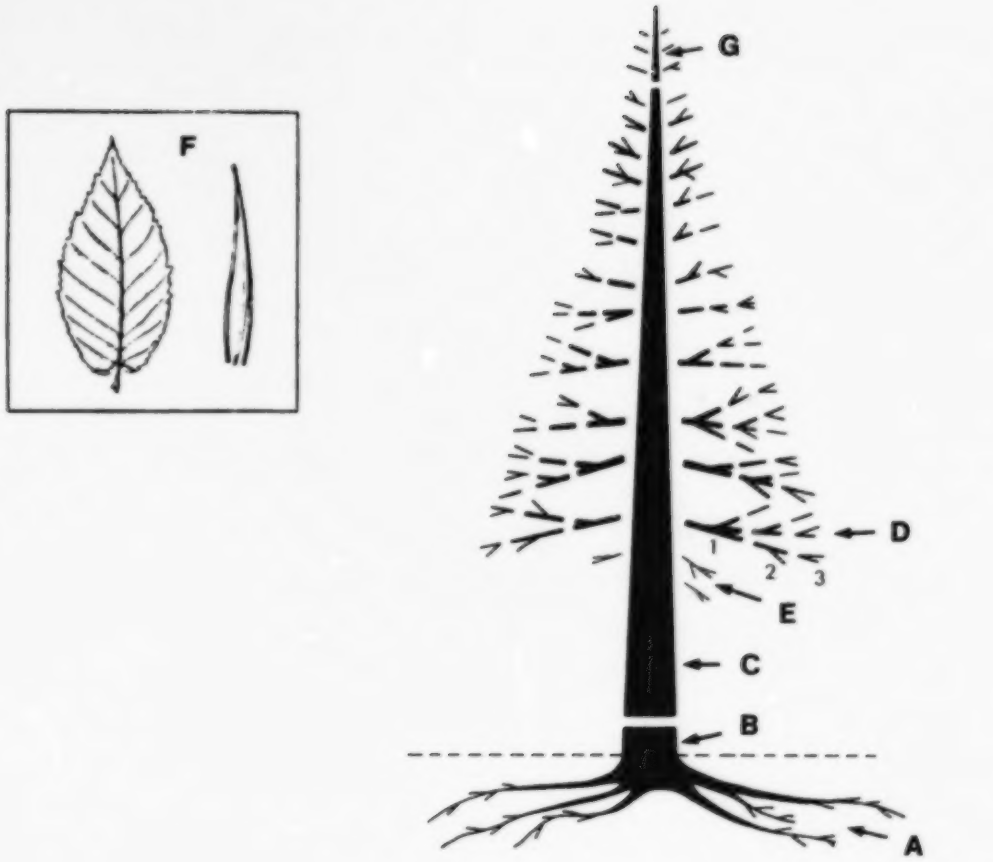
Live branches (including the top) were sorted into three basal diameter classes and weighed to determine the total fresh mass in each class. Two randomly selected branches from each of the basal diameter classes were sub-sampled to determine the proportion of each of the three branch size classes within a basal diameter class. The mass of dead branches was determined directly by weighing in the field.

The fresh mass of bole sample discs and crown subsamples was measured at the field base camp within 24 hours of cutting to determine the ratios of fresh wood mass to bark mass and the proportion of fresh mass in each of the three branch size classes. For fresh mass, foliage was included with the smallest branch size class but was later calculated separately based on dry mass ratios.

Each sample was labelled and stored at the base camp until shipment to the laboratory in Vancouver (at one- to two-week intervals). Just prior to shipment, samples were sealed in plastic bags Transit time to the laboratory was usually one or two days.

Other Data Collected

Diameter at breast height outside bark (Dbh), total tree height (H), crown width (CW) and crown length (CL) were measured and recorded for each sample tree. Dbh was measured to the nearest 0.1 cm and H, CW and CL to the nearest 0.1 m. Crown width was recorded as the average of two orthogonal axes measured at the base of the live crown. Age was recorded for each sample tree based on a ring count at a height of 30 cm and B.C. Ministry of Forests age correction tables. Other information of interest which was recorded included the following:



A — below ground components
roots and stump

B — Stump above ground
30 cm above point
of germination

C — Bole
to a 2.5 cm diameter top
Bole wood and bark
are measured separately

D — Live Branches
size class 1 >2.5 cm
size class 2 0.5-2.5 cm
size class 3 <0.5 cm

E — Dead Branches

F — Foliage

G — Top
<2.5 cm diameter
included in appropriate
branch size classes

Figure 1. Tree biomass components as defined for this study

Modified from Young, H.E., L. Strand and R. Alterberger. 1964. Preliminary fresh and dry weight tables for seven tree species in Maine. Maine Agr. Exp. Sta., Orono, Maine. Tech. Bull. 12: 76 p. in Stanek and State, 1978.

Section F from Brayshaw, T.C. 1963. Key to the native trees of Canada. Can. Dept. Forestry Bull. 125. Min. of Forests. Ottawa.

1) crown class (dominant, codominant or intermediate)

2) total (inside bark) wood volume

3) latitude and longitude of the sample location (to the nearest 15 seconds)

4) elevation (to the nearest 50 m a.s.l.)

5) biogeoclimatic zone (defined by Krajina in Farley (1979))

6) stand density in cubic metres per hectare

7) crown closure (ocular estimate, to the nearest 10%)

8) site position (e.g., upper slope, mid-slope, lower slope, etc.)

9) a general description of dominant understory vegetation

The B.C. Ministry of Forests has developed a system of biogeoclimatic zones which differs from the one originally developed by Krajina. Since maps were not available for the Ministry of Forests' system covering all areas of this study, Krajina's system was used. Those wishing to relate the sample trees to other classifications or maps can do so using the information on latitude, longitude and elevation recorded for each sample tree.

Laboratory Processing

Upon arrival at the laboratory, samples were promptly unpacked and laid out on a trestle table for preliminary drying at ambient temperature. Samples were then dried in large, forced-air drying ovens equipped with constant temperature controls. Drying times ranged from 24 to 48 hours depending on the moisture content, size and type of sample. After removal from the ovens, the samples were allowed to cool for 15 minutes before weighing.

The immersion technique outlined in Appendix C was used to determine the volumes of oven-dry wood and bank for sample discs from large bole sections.

Data Processing

Entries on the data form for each tree were checked at the time of laboratory processing and again when all sampling for the year had been completed. Errors, omissions or inconsistencies were corrected, sometimes by reference to the original field notes and samples. Following visual checking, data were keypunched, verified and transferred to computer tape. The data were then processed by a computer program which re-edited the data, produced a tabulated output of all data and biomass measurements for each tree, and produced a computer file for statistical analyses. Complete data printouts were produced during the winter following each field season. Data editing included calculation of various results for each biomass sample, such as the percentages of fresh wood, dry wood, bark, foliage, and the density. Inconsistent results or results outside pre-determined ranges were flagged for further checking.

Regression Analysis

Preliminary analysis was conducted based on the data sets collected during the 1980 field season for ponderosa pine and western larch using simple and multiple linear and logarithmic models with Dbh, H, D^2H, CW and CL as independent variables. During 1982, detailed preliminary analyses of large data sets for five species were conducted; simple and multiple linear as well as non-linear models were tested using Dbh, H, volume(V) and their interactions as independent variables. Volume as used in the discussion of regression equations refers to the total inside bark wood volume predicted from B.C. Ministry of Forests metric volume equations (Forest Inventory Division 1976). Based on the results of the detailed analysis, final regression equations were produced.

Both stepwise and elimination procedures were used in computing multiple linear regressions. Equations were first fitted to all components. These equations were studied and a compromise equation giving the best overall results for all components was selected. This compromise equation was then fitted for all components without eliminating any of the previously selected variables.

Many potential independent variables were essentially interchangeable with respect to their effect when added to the model. In such cases, variables were selected to be consistent within similar groups of tree species or varieties. For example, all *Pinus* species use V and D^2 and both *Tsuga* species use V, D^2V and DHV.

In order to use volume as an independent variable, the appropriate Ministry of Forests volume equations must be used. In most cases this requires relating a sample tree to a volume equation by forest inventory zone and age class. For example there are three volume equations for western hemlock: two for the Coast and one for the Interior. The two Coastal equations are for ages up to 120 years and greater than 120 years; the Interior equation covers all age classes. In other cases (such as with Interior *Picea* and, to some degree, *Abies*) species are aggregated in the volume equations. No volume equations are available for mountain hemlock and shore pine, so the equations for western hemlock and lodgepole pine, respectively, were used.

Results and Discussion

A total of 1155 trees were sampled and 20 730 samples were processed. Generally 40 or more trees were sampled for each species or variety; the actual number ranged from 39 for mountain hemlock to 105 for white spruce. Information on the number of sample trees and the range, mean and median Dbh, height and age for each species or variety is shown at the top of each species table in Appendix A. Approximate sampling locations are shown in Figure 2.

Preliminary analysis conducted during 1981 of the data sets for ponderosa pine and western larch suggested that simple linear equations using D^2H gave good predictions of bole wood, bark and total mass but often performed poorly for crown components. In order to confirm these results and to select regression models that suit the objectives of the study, a more detailed analysis was conducted during 1982. Data were analyzed for five species: white spruce, lodgepole pine, subalpine fir, western hemlock and western red cedar. These species give a representative cross section of variability in stem, branch and foliage characteristics for the coniferous species in this study. Hardwood species were not analyzed because sufficient data were not available at the time. Analyses were conducted on oven-dry biomass data only.

Comparison of Various Prediction Models and Use of V as an Independent Variable

The symbols used in the following discussion are defined as follows:

D = Dbh ob cm
H = total height in m
V = volume inside bark, predicted from B.C. Ministry of Forests volume equations in m^3
B = biomass component mass in kg
n = number of samples
SEE = standard error of the estimate
MSE = mean square error
RE = relative efficiency

Several biomass prediction models were tested and compared:

$$B = b_1D^2H \quad (1)$$

$$B = b_0 + b_1D^2H \quad (2)$$

$$B = b_0 + b_1D + b_2D^2 + b_3H + b_4D^2H + b_5DH^2 \quad (3)$$

$$B = b_1D^{b_2}H^{b_3} \quad (4)$$

$$B = b_0 + b_1D + b_2D^2 + b_3V + b_4d^2V + b_5HV + b_6D^2HV + b_7DHV \quad (5)^1$$

Given the strong relationship between volume and biomass, the potential wealth of information in tree volume data and equations available from

[1] Not all terms in this model are used for each individual species. See Table 4 for independent variables selected in each case.

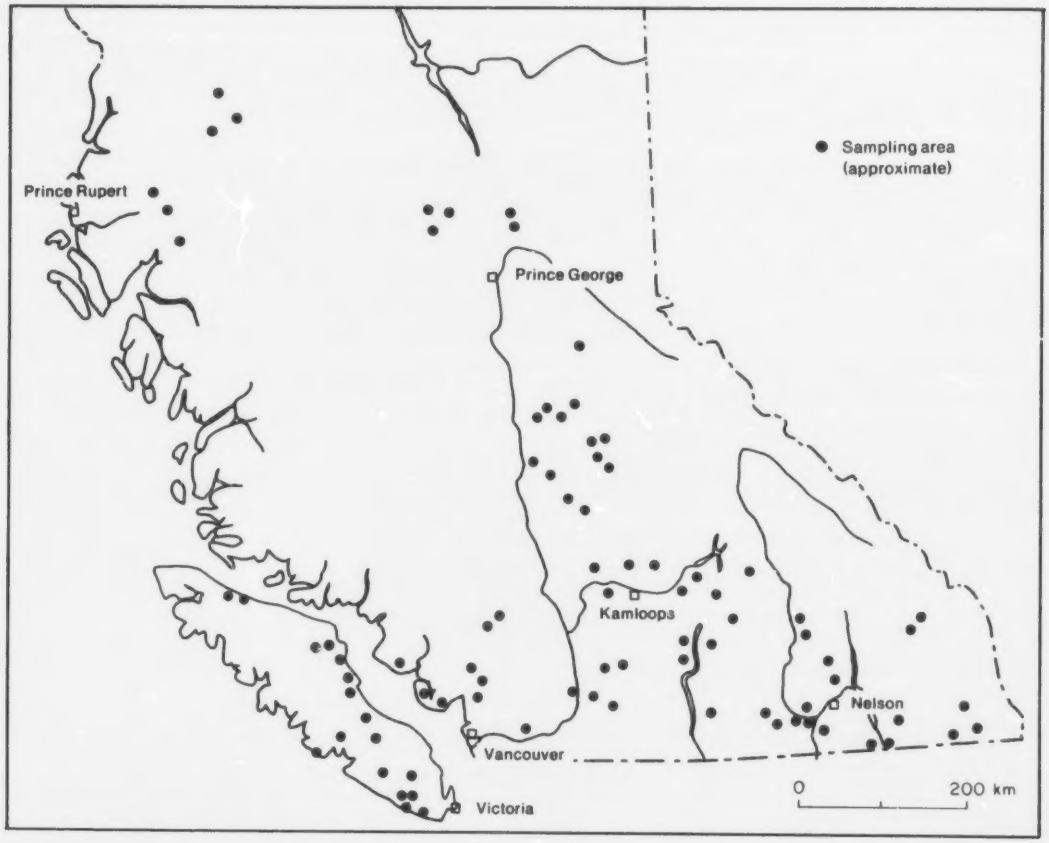


Figure 2. Approximate sampling areas

the B.C. Ministry of Forests should be used. The volume equations are based on a total of 34 641 sample trees collected over a wide range of size classes, stand conditions and geographic areas; the number of sample trees for each equation applicable to this study ranges from 302 for yellow cedar to 4452 for white spruce (Forest Inventory Division 1976). The volume equations are used to test the potential value of V as an independent variable.

Used in this way, V provides a point estimate that is a nonlinear transformation, similar to D^2H. In fact, the volume equations are derived from the general model:

$$\text{Volume} = b_1 D^{b_2} H^{b_3} \qquad (6)$$

and D^2H is a special case of (6) where $b_1 = 1$, $b_2 = 2$ and $b_3 = 1$. A potential advantage of V is that it should provide better estimates of the coefficients (b_1, b_2, and b_3). Broadly speaking, the use of V can be thought of as analogous to two-phase sampling where the volume sample represents the first phase and the biomass samples are the subsample. Of course, the analogy is not strictly correct because the trees sampled for biomass in this study are not a subset of the B.C. Ministry of Forests' volume samples.

Even where no clear statistical improvement can be seen from using V, it may give more accurate predictions than D^2H when biomass equations are applied to an independent sample (if V is, in fact, a better predictor of true volume). However, this cannot be tested from analysis of the data on hand.

Simple linear equations using D^2H as the independent variable (models 1 and 2) are attractive

because of their simplicity. However, the relationship between biomass of components and D^2H for the species studied is not linear and does not pass through the origin (i.e., an intercept is required). Plotting of residuals and comparison of standard error and confidence limits indicate that models 1 and 2 are not as precise as 3, 4 and 5.

Multiple linear equations based on D, H and their interactions (model 3) are much more precise than models 1 and 2. All five independent variables are not needed for every species; two or three are often sufficient. However, all of the same independent variables should be retained for all biomass components within a species so that simple additivity of the coefficients is possible (Kozak 1970).

Non-linear regression equations such as model 4 perform comparably or nearly as well as model 3 for most species. However, calculations and interpretations are more complex, and regression coefficients for the components are not additive.

Using V as an independent variable together with D, H and/or various interaction terms (model 5) results in a multiple linear equation which is, for many species and components, more precise than any of the other models tested. As in model 3, not all independent variables are needed for all species but, within a species, the same variables are retained for all biomass components to allow simple additivity.

Comparisons of standard errors of the estimate were made for all five species and all oven-dry biomass components. On this basis, models 3, 4 and 5 are superior to models 1 and 2; models 3 and 4 are approximately comparable and model 5 is the best. This is illustrated in Table 1 which compares the standard errors for several biomass components for white spruce based on a sample of 100 trees; comparisons for the other four species are similar.

The Contribution of Volume as an Independent Variable

Comparing models 3 and 5, the gains from including V and its interactions, in addition to D and H, appear to be marginal for some compo-

Table 1

Standard error of the estimate (oven-dry kg) for white spruce for different biomass models[a] (n = 100)

Biomass Component	Regression Model				
	1	2	3	4	5
Wood	33.519	33.2397	30.601	30.409	23.700
Bark	6.598	6.048	4.085	4.184	3.903
Branch Class 2	15.404	17.786	8.957	9.835	8.021
Foliage	19.396	17.394	13.323	13.224	10.487
TOTAL	71.328	66.092	45.364	46.664	36.023

[a] From preliminary analysis conducted in 1982.

Table 2

Relative efficiency of Model 5 compared to model 3[a]

Tree Species	n	Biomass Component oven-dry	
		Foliage	Total
White spruce	100	1.61	1.59
Western red cedar	50	1.38	1.02
Lodgepole pine	80	1.53	1.09
Western hemlock	48	1.15	1.10
Subalpine fir	74	1.75	1.60

[a] From preliminary analysis conducted in 1982.

nents in some species; however, model 5 is generally superior. The degree of improvement associated with the use of V depends on the variability within species, characteristics of the sample and the accuracy of existing volume equations.

The relative efficiency of model 5 to model 3 is given by:

$$RE = \frac{MSE(3)}{MSE(5)}$$

Table 2 shows the relative efficiency gain resulting from the inclusion of V and its interactions for oven-dry total and foliar biomass for the five species tested.

Final Regression Analysis

Following the preliminary analyses, two regression models were chosen: a simple linear equation with an intercept using D^2H as the independent variable (model 2) and a multiple linear equation using V, D, H and interactions (model 5). Both models (2 and 5) were computed for the 22 tree species and varieties (Appendix D), for all components for both fresh and oven-dry biomass (only results for oven-dry biomass are reported here). A detailed summary of the results, including equations, is presented in Appendix A. Coefficients of determination and 95% confidence limits (for average observations, at the mean) expressed as a percentage of the mean for oven-dry total and foliar mass of each species are summarized in Table 3. Independent variables selected for multiple regression are shown in Table 4.

In general, both simple linear and multiple linear models give good results for prediction of bole components and total biomass. The multiple linear equations show some improvement in precision over simple linear equations as indicated by the relative efficiencies (RE) shown in Table 5. The degree of improvement varies according to species and component but occurs most consistently in crown components. However, considerable improvements in precision are also shown in bole wood for western red cedar, ponderosa pine and red alder and somewhat lesser gains for western hemlock, Pacific silver fir, western larch and black spruce. Some improvements are also evident in the bark component for both hemlock species and red alder.

White birch is the only species in which no gain is evident in any component from using model (5). At the other extreme, species such as Coastal

Table 3

Adjusted R^2 and 95% confidence limits[a] for the mean (CL in %) for simple linear (2) and multiple linear (5) models for oven-dry total and foliar biomass

Species	Total				Foliage			
	r^2	R^2	CL_2	CL_5	r^2	R^2	CL_2	CL_5
Coastal Douglas-fir	0.99	0.99	5.6	3.8	0.56	0.83	24.3	14.8
Sitka spruce	0.96	0.98	8.2	5.3	0.46	0.89	30.6	14.0
Western red cedar	0.97	0.99	6.3	4.5	0.62	0.84	22.7	14.6
Interior Douglas-fir	0.84	0.88	14.9	10.2	0.40	0.74	27.6	18.0
Ponderosa pine	0.98	0.98	5.8	5.6	0.40	0.53	29.0	25.4
Western hemlock	0.98	0.99	7.8	5.2	0.57	0.85	23.4	13.8
White spruce	0.96	0.98	5.7	4.3	0.44	0.68	17.7	13.4
Engelmann spruce	0.98	0.98	5.6	5.3	0.37	0.49	20.7	18.6
Pacific silver fir	0.96	0.97	6.0	5.8	0.54	0.78	19.6	13.7
Grand fir	0.96	0.96	6.3	6.2	0.46	0.64	23.0	18.7
Western larch	0.88	0.94	12.6	9.1	0.19	0.47	35.9	29.5
Western white pine	0.96	0.97	9.3	8.2	0.37	0.60	29.0	23.2
Lodgepole pine	0.93	0.96	6.0	4.2	0.24	0.58	20.4	15.3
Mountain hemlock	0.99	0.99	3.4	3.6	0.63	0.74	24.8	20.4
Black spruce	0.97	0.98	4.3	3.4	0.41	0.68	24.0	17.3
Subalpine fir	0.95	0.97	7.0	5.2	0.56	0.75	19.5	14.8
Yellow cedar	0.99	0.98	6.2	6.7	0.59	0.67	18.3	16.4
Black cottonwood	0.95	0.95	7.7	7.6	0.55	0.56	25.5	25.5
Red alder	0.99	0.99	5.5	4.3	0.02	0.65	27.6	17.2
Trembling aspen	0.94	0.94	7.1	7.1	0.37	0.37	29.0	29.0
White birch	0.96	0.96	6.3	6.7	0.61	0.61	15.7	15.7
Shore pine	0.98	0.98	4.8	3.9	0.71	0.77	17.3	15.3

[a] R^2 is rounded to the nearest 0.01 (except for total biomass for Coastal Douglas-fir which would round to 1.00) and CL to the nearest 0.1%; CL in Kg is given in Appendix A.

Douglas-fir, Sitka spruce, western red cedar, western hemlock, white spruce, western larch, subalpine fir and red alder show generally good gains. The remaining species show some reasonable gains in one or more components; for example, Interior Douglas-fir shows considerable gain in the foliage component, lesser gains in branch classes 2 and 3 and a somewhat smaller gain in total biomass. Evaluation of the results for some species such as mountain hemlock and yellow cedar is more difficult because, although gains are made for some components, RE is less for total biomass.

Lack of improvement from using model 5 is probably related to how closely the biomass samples represent the B.C. Ministry of Forests' volume samples. In the case of mountain hemlock, there is no specific volume equation available (western hemlock volume equations are used). All *Abies* species are lumped together in the volume equations and the volume samples are dominated by Pacific silver fir on the coast and subalpine fir in the interior; this may explain

Table 4

Independent variables selected
for multiple regression equations (model 5)

Species	Independent Variables
Coastal Douglas-fir	V, D^2
Sitka spruce	V, HV
Western red cedar	V, D^2
Interior Douglas-fir	V, D^2, D^2HV
Ponderosa pine	V, D^2
Western hemlock	V, DHV, D^2V
White spruce	V, D^2
Engelmann spruce	V, D^2
Pacific silver fir	V, D^2
Grand fir	V, D^2
Western larch	V, HV
Western white pine	V, D^2
Lodgepole pine	V, D^2
Mountain hemlock	V, DHV, D^2V
Black spruce	V, D^2, D^2V
Subalpine fir	V, D^2, D
Yellow cedar	V, D^2
Black cottonwood	V, D^2
Red alder	V, D^2
Trembling aspen	V, D^2
White birch	V, D^2
Shore pine	V, D^2

the lack of improvement in grand fir from using the multiple linear model with V. The lack of improvement for other species such as yellow cedar and white birch is less clearly explained.

Coefficients of determination for total oven-dry biomass are generally 0.95 or greater except for Interior Douglas-fir ($r^2 = 0.84$, $R^2 = 0.88$), western larch ($r^2 = 0.88$, $R^2 = 0.94$), lodgepole pine ($r^2 = 0.93$, $R^2 = 0.96$) and trembling aspen ($r^2 = R^2 = 0.94$); values for bole wood and bark are similar but often slightly less. Values for crown components are less and extremely variable, ranging from about 0.26 for branch class 2 in trembling aspen to 0.91 for branch class 2 in subalpine fir. The extreme value of $r^2 = R^2 = 0.00$ for branch class 3 in ponderosa pine shown in Appendix A is a result of the scarcity of small branches on the sample trees; most samples had no branches in that size class and branch class 3 generally represents less than 1% of the total dry mass of the crown.

The 95% confidence limits expressed as a percentage of the mean for multiple linear equations are generally in the 5-6% range for total oven-dry biomass and 15-20% for foliage. Confidence limits are more variable and often much greater for the three branch classes. Branch class 1 is particularly variable because zero values occur often for all species; confidence limits for oven-dry branch class 1 generally range from 20-30%. Higher values often occur but these represent very small portions of total crown or total aboveground biomass. For example, the confidence limits for black spruce are about 90% but this represents, in absolute terms, an error of 0.8 kg (at the mean); a similar situation exists for western red cedar, Pacific silver fir and grand fir and branch class 3 in ponderosa pine and black cottonwood.

As a further test of the applicability of the equations, the data sets for white spruce (105 trees) and lodgepole pine (98 trees) were each divided into two samples, regression equations were computed for each sample and predictions were compared with the data for the samples within each species. The results of these cross-validations supported the magnitude and 95% confidence limits reported in Table 3 and Appendix A.

A major criterion used to evaluate different regression models and the use of V as an independent variable is precision, expressed by SEE, 95% confidence limits and RE. Choice of a most suitable model or equation cannot be made simply on the basis of a single criterion. Other criteria used to assess regression models in this study were the following:

1) additivity of coefficients

2) precision — determined by plotting and examining residuals

3) accuracy - R^2 and confidence limits (goodness of fit) — indicated by adjusted R^2 values

4) degeneracy — how well the equations predict biomass near the extremes of the sampled tree sizes.

Table 5

Relative efficiency[a] of model 5 compared to model 2[b]

Species	Biomass Component						
	Wood	Bark	Branches (1)	Branches (2)	Branches (3)	Foliage	Total
Coastal Douglas-fir	1.21	1.17	1.21	2.28	2.02	2.66	2.02
Sitka spruce	1.34	1.17	1.80	3.84	1.99	4.75	2.34
Western red cedar	1.77	1.17	2.43	1.69	1.35	2.46	1.99
Interior Douglas-fir	1.12	1.10	0.98	1.51	1.56	2.31	1.37
Ponderosa pine	1.96	1.10	1.72	1.64	1.00	1.28	1.08
Western hemlock	1.54	1.80	2.25	2.31	3.69	2.89	2.25
White spruce	1.14	1.19	1.59	2.62	1.61	1.74	1.80
Engelmann spruce	1.17	1.14	1.25	1.37	1.59	1.23	1.12
Pacific silver fir	1.44	1.02	0.98	1.88	1.51	2.13	1.08
Grand fir	0.94	1.12	1.82	1.00	1.54	1.51	1.02
Western larch	1.59	1.00	1.49	1.80	2.28	1.54	1.90
Western white pine	0.98	1.08	1.35	1.21	1.06	1.61	1.30
Lodgepole pine	1.42	1.46	1.54	1.77	1.39	1.80	1.99
Mountain hemlock	1.25	1.85	2.79	1.12	1.10	1.39	0.88
Black spruce	1.56	1.04	1.37	1.85	1.61	1.82	1.61
Subalpine fir	1.21	1.06	2.04	2.46	1.39	1.77	1.85
Yellow cedar	0.96	1.10	1.10	1.25	1.77	1.25	0.86
Black cottonwood	1.39	1.08	1.17	1.64	1.17	1.04	1.02
Red alder	2.19	1.82	2.40	2.56	2.66	2.79	1.61
Trembling aspen	0.98	1.04	1.25	1.02	1.80	1.00	1.06
White birch	0.90	0.94	1.00	0.96	0.98	1.00	0.90
Shore pine	1.19	1.04	1.54	1.61	1.46	1.23	1.51

[a] $RE = \frac{MSE_2}{MSE_5}$ MSE = mean square error; simple linear = 2; multiple linear = 5

[b] based on oven-dry biomass data.

Additivity of Coefficients

The requirement of additivity effectively ruled out the use of logarithmic or non-linear regression models. Adjusted, weighted linear models described by Lavigne and van Nostrand (1981) were not calculated because of the considerable variability in the behaviour of most biomass components. Also, since predictions of total mass, bole wood mass and bark mass, even for unweighted, simple linear equations, are adequately precise and reasonably accurate while estimates of crown components are relatively imprecise, it seems that little would be gained by adjusting the regression coefficients for crown components such as foliage. Therefore, the models of choice were unweighted simple and multiple linear models. All models suggested by this study are additive since the same variables were used for all components within a given species (or variety). However, recently reported alternative methods of obtaining additivity (Cunia

and Briggs 1984; Chiyenda and Kozak 1984) could be applied.

Precision

Examination of residuals shows that the assumptions of homogeneous variance and normality are not met by the simple linear equations or, in many cases, by the multiple linear equations. Western larch, ponderosa pine and Engelmann spruce are examples of species showing considerable heterogeneity of variance (Appendix A) with either regression model. Therefore, the SEE and confidence limits reported should be regarded as approximations. However, cross validation of the data for white spruce and lodgepole pine indicates that the reported confidence limits are realistic.

Relatively low R^2 values found for many crown components and species indicate a weak relationship to tree size (expressed by Dbh, H and V); similar results have been reported in other studies, for example, by Alemdag (1982). The coefficient of determination is probably affected by species characteristics, stand and site conditions, and by characteristics of the sample for each species.

In some cases, low R^2 values reflect the arbitrariness of branch size class definitions. For example, branch class 1 was often absent from sample trees of all species and branch class 3 was almost always absent in ponderosa pine.

Compared to stemwood and bark, crown components are greatly affected by relatively short-term changes in stand and site conditions. The inclusion of independent variables reflecting stand density and age might improve the goodness of fit and precision of estimates for crown components (Alemdag and Stiell 1982; Madgwick and Kreh 1980).

Accuracy

Extensive plottings of the results and detailed analysis did not indicate any significant bias or lack of fit for most species.

Degeneracy

In general, both simple and multiple linear regression models give reasonable predictions throughout the range of the sample. Predictions from the multiple linear equations for components of some very small trees near the lower limits of the sample can be zero or slightly negative depending on the dimensions of a particular tree, the characteristics of the sample, and the characteristics of the equations. The simple linear equations behave similarly for some components (commonly branch class 1) for several species.

Extrapolation

Predictions for large trees well beyond the range of tree size for a sample are obviously inaccurate for multiple linear equations for some components of all species and for total biomass of several species. This results from negative coefficients for some variables causing biomass estimates to reach a maximum at some point beyond the sample range and then decrease. An extreme example of this is the multiple linear equation for Sitka spruce; a tree with a Dbh of 100 cm and a height of 45 m has a negative biomass predicted. This problem does not occur with the simple linear equations.

Even when obviously unrealistic predictions do not occur, extrapolation beyond the range of a sample is not justified by regression theory. Such predictions may be reasonable approximations of stem and total biomass but they should be regarded with caution. Statistics for the equations, such as R^2 or SEE, are not applicable to such extrapolations.

The sampling conducted in this study was aimed at a range of tree sizes which would be found in second growth stands. Sampling was, of necessity, further constrained by budgetary and access limitations. However, with the possible exception of Sitka spruce and yellow cedar, the objectives of the project have been achieved.

Time-Related Variability

Sampling was conducted during three consecutive field seasons over periods of about four to

six months so that seasonal fluctuations in tree water content and in dry biomass of crown components are largely represented in the error term (residual mean square) for the equations. However, given the potentially large degree of variability in water content (Kramer and Kozlowski 1979; Hinckley *et al.* 1978; Waring and Running 1978), predictions of fresh biomass may not always be as reliable as indicated by the statistics presented in this report. Fresh mass estimates are further complicated because of the definition of crown components for fresh mass; for example, reproductive structures such as strobili and cones are included with their associated branch size class (usually class 3 which also includes foliage).

Some of the variability in crown components, particularly foliage, is probably attributable to variable rates of shoot growth and leaf expansion. Such variability may be especially important with respect to the relatively weak relationships between tree size and biomass of some crown components for species such as western larch, black cottonwood and trembling aspen which exhibit rapid expansion of short shoots followed by a gradual expansion of long shoots. A further complication is that this growth habit changes with tree age; shoot growth in mature trees is mainly by short shoots (Kramer and Kowzlowski 1979).

With the exceptions of Coastal Douglas-fir, Sitka spruce, black cottonwood, red alder and shore pine, some old growth trees had to be sampled to represent larger tree sizes. In older trees there is generally more biomass in the bole and proportionally less in the crown (Kramer and Kowzlowski 1979; Ovington and Madgwick 1959; Whittaker and Woodwell 1967). The inclusion of a few relatively old, large trees in a sample may further contribute to the non-linearity of tree size and crown component relationships.

Literature Cited

Alemdag, I.S. 1980. Manual for data collection and processing for the development of forest biomass relationships. Can. For. Serv. Pet. Natl. For. Inst. Inf. Rep. PI-X-4.

— — — —. 1982. Aboveground dry matter of jack pine, black spruce, white spruce and balsam fir trees at two localities in Ontario. For. Chron. 58(1): 26-30.

Alemdag, I.S. and Stiell, W.M. 1982. Spacing and age effects on biomass production in red pine plantations. For. Chron. 58(5): 220-224.

Bonner, G.M. 1979. Development of forest biomass inventory methodology in Canada. pp. 736-744 IN: Workshop proceedings: forest resource inventories. Vol. II. Colorado State Univ. Fort Collins, Col. 80523.

Chiyenda, S.S. and A. Kozak. 1984. Additivity of component biomass equations when the underlying model is linear. Can. J. For. Res. 14(3): 441-446.

Cunia, T. 1979. On tree biomass tables and regression: some statistical comments. pp. 629-642 IN: Workshop proceedings: forest resource inventories. Vol. II. Colorado State Univ. Fort Collins, Col. 80523.

Cunia, T. and R.D. Briggs. 1984. Forcing additivity of biomass tables: some empirical results. Can. J. For. Res. 14(3): 376-384.

Demaerschalk, J.P. and A. Kozak. 1974. Suggestions and criteria for more effective regression sampling. Can. J. For. Res. 4(3): 341-348.

Dobbs, R.C. 1981. The ENFOR production program. pp. 1-16 IN: Proceedings: third bioenergy R & D seminar. March 24-25, 1981, Ottawa, Can. Sponsored by: Energy Project Office, Natl. Res. Council of Canada. Ottawa, Ont. Canada. 373 p.

Evert, F. and I.S. Alemdag. 1979. Review letter in For. Chron. 55(5): 209-210: Equations predicting primary productivity (biomass) of trees shrubs and lesser vegetation based on current literature. W. Stanek and D. State. Env. Can. Can. For. Serv. Victoria, B.C. Inf. Rep. BC-X-183.

Farley, A.L. 1979. Atlas of British Columbia. Univ. of B.C. Press. Vancouver, B.C.

Forest Inventory Division. 1976. Whole stem cubic metre volume equations and tables: centimetre diameter class merchantable volume factors. B.C. For. Serv. Victoria, B.C.

Hinckley, T.M., J.P. Lassoie and S.W. Running. 1978. Temporal and spatial variations in the water status of forest trees. For. Sci. Monograph 20. pp. 44-45.

Kozak, A. 1970. Methods of ensuring additivity of biomass components by regression analysis. For. Chron. 46(5): 402-404.

Kramer, P.J. and T.T. Kozlowski. 1979. Physiology of woody plants. Academic Press, N.Y. pp. 65-78, 479-480, 546-551 & 597-602.

Lavigne, M.B. and R.S. van Nostrand. 1981. Biomass equations for six tree species in central Newfoundland. Env. Can. Can. For. Serv. Newfoundland For. Res. Centre. St. Johns, Newfoundland. Inf. Rep. N-X-199.

Love, P. 1980. Biomass energy in Canada: its potential contribution to future energy supply. Min. of Supply and Serv. Can. Cat. No. M23-14/80-4-1E. Beauregard Press Limited.

Madgwick, H.A.I. and R.E. Kreh. 1980. Biomass estimation for Virginia pine trees and stands. For. Sci. 26(1): 107-111.

Massie, M.R.C. 1983. Development of biomass prediction equations for Yukon tree species. Nawitka Renewable Resource Consultants Ltd. for the Canadian Forestry Service.

McDaniels, T.L. 1981. Forest biomass energy in British Columbia: opportunities, impacts and constraints. pp. 181-182 IN: Proceedings; third bioenergy R & D seminar. March 24-25, 1981, Ottawa, Ont. Sponsored by: Energy Project Office, Natl. Res. Council of Can. Ottawa, Ont. Can.

Ovington, J.D. and H.A.I. Madgwick. 1959. The growth and composition of mature stands of birch. I. Dry matter production. Plant Soil 10: 271-283.

Stanek, W. and D. State. 1978. Equations, predicting primary productivity (biomass) of trees, shrubs and lesser vegetation based on current literature. Env. Can. Can. For. Serv. Victoria, B.C. Inf. Rep. BC-X-183.

Waring, R.H. and S.W. Running. 1978. Sapwood water storage: its contribution to transpiration and effect upon water conductance through the stems of old growth Douglas-fir. Plant, Cell and Environ. 1: 131-140.

Whittaker, R.H. and G.M. Woodwell. 1967. Surface area relations of woody plants and forest communities. Amer. J. Bot. 54(8): 931-939.

BRITISH COLUMBIA TREE BIOMASS REGRESSION ANALYSIS

01 COAST DOUGLAS FIR
(49 TREES)

	DBH(cm)	HEIGHT(m)	AGE(yrs)
MAXIMUM	66.0	44 0	86
MEAN	21 2	15 1	31
MEDIAN	14 1	10 9	22
MINIMUM	4 5	4 1	9

COM-PONENT	MEAN	S.D	MIN	MAX	y = a + bDDH RSQ	a	b	95% CONFIDENCE INTERVAL FOR THE MEAN	y = a + bV + cDD RSQ	a	b	c	95% CONFIDENCE INTERVAL FOR THE MEAN
DWOOD	253 6	332 5	2 0	2044 9	0 99	10 3	110 4	242 6 - 264 6	1 00	-1 5	415 4	123 1	243 6 - 263 6
DBARK	37 6	75 9	0 5	291 9	0 98	3 1	15 6	34 8 - 40 4	0 98	0 1	51 4	99 1	35 0 - 40 2
DBRAN1	14 7	36 2	0 0	174 2	0 64	1 4	6 0	8 6 - 20 8	0 70	-10 5	-39 8	686 7	9 2 - 20 2
DBRAN2	13 7	15 2	1 0	61 5	0 45	9 0	2 2	10 6 - 16 9	0 76	-1 3	-48 2	614 0	11 6 - 15 8
DBRAN3	5 8	7 4	0 0	32 0	0 56	3 2	1 2	4 4 - 7 2	0 81	-1 3	-20 2	268 6	4 9 - 6 7
DFOLI	18 9	24 7	0 3	129 3	0 56	10 3	3 9	14 3 - 23 5	0 83	-5 5	-72 1	946 4	16 1 - 21 7
DTOTAL	344 3	673 5	5 3	2935 6	0 99	37 3	139 3	324 9 - 363 7	0 99	-20 0	286 5	2737 9	330 6 - 357 9
FWOOD	458 9	926 1	4 2	3528 1	0 99	37 0	191 4	431 0 - 486 8	0 99	-27 0	475 4	2874 0	435 3 - 482 5
FBARK	73 6	140 1	1 2	535 3	0 99	9 8	28 9	69 2 - 78 0	0 99	0 1	72 4	430 9	70 2 - 77 0
FBRAN1	26 1	67 6	0 0	330 4	0 62	1 6	11 1	14 5 - 37 8	0 68	-19 6	-70 2	1230 2	15 4 - 36 8
FBRAN2	27 9	30 9	2 1	131 0	0 46	18 2	4 4	21 6 - 34 3	0 76	-2 4	-95 0	1227 3	23 7 - 32 2
FBRAN3	12 4	14 4	0 9	63 9	0 60	7 2	2 3	9 9 - 14 9	0 83	-1 2	-36 8	498 9	10 7 - 14 1
FFOLI	40 6	49 3	0 6	239 5	0 58	23 2	7 9	31 7 - 49 5	0 83	-6 9	-134 2	1790 4	35 0 - 46 2
FTOTAL	639 6	1196 8	12 5	4489 8	0 98	97 1	246 1	590 7 - 688 5	0 99	-57 0	210 8	8051 8	606 0 - 673 3
FDEAD	3 7	5 5	0 1	22 5	0 69	1 6	1 0	2 9 - 4 6	0 68	1 1	1 5	24 1	2 9 - 4 6

NOTE D - Diameter at breast height in metres
H - Height in metres
V - Volume inside bark in cubic metres

Appendix A
Equations

BRITISH COLUMBIA TREE BIOMASS REGRESSION ANALYSIS

02 SITKA SPRUCE
(40 TREES)

	DBH(cm)	HEIGHT(m)	AGE(yrs)
MAXIMUM	45.1	22.5	78
MEAN	16.9	11.1	30
MEDIAN	13.0	10.4	30
MINIMUM	5.3	4.6	13

COM-PONENT	MEAN	S.D.	MIN.	MAX.	y = a + bDDH RSQ	a	b	95% CONFIDENCE INTERVAL FOR THE MEAN	y = a + bV + cHV RSQ	a	b	c	95% CONFIDENCE INTERVAL FOR THE MEAN
DWOOD	64.5	103.3	4.2	569.3	0.98	-1.0	117.4	59.7 - 69.4	0.98	3.8	167.8	10.6	60.3 - 68.7
DBARK	8.5	11.4	0.5	54.4	0.93	1.3	12.6	7.6 - 9.4	0.94	1.0	43.4	-0.1	7.6 - 9.3
DBRAN1	4.0	8.8	0.0	43.7	0.42	0.3	6.7	1.9 - 6.1	0.68	-4.0	117.4	-4.6	2.5 - 5.6
DBRAN2	13.0	14.1	1.6	79.0	0.41	6.7	10.5	9.6 - 16.3	0.85	-0.7	233.7	-9.5	11.2 - 14.7
DBRAN3	5.5	6.3	0.4	27.1	0.41	2.7	4.8	4.0 - 7.0	0.71	-0.1	88.9	-3.5	4.4 - 6.6
DFOLI	19.3	25.6	1.1	141.6	0.46	7.6	20.1	13.5 - 25.2	0.89	-6.7	424.5	-17.2	16.6 - 22.0
DTOTAL	113.9	152.7	4.7	723.4	0.96	17.6	172.1	104.6 - 123.2	0.98	-6.7	1075.8	-24.3	107.8 - 119.9
FWOOD	143.0	221.6	9.8	1233.0	0.98	2.0	252.1	133.4 - 152.7	0.97	-2.1	731.8	4.8	131.3 - 154.7
FBARK	19.3	25.5	1.4	131.1	0.97	3.1	28.8	17.8 - 20.7	0.97	2.7	86.5	0.4	18.0 - 20.6
FBRAN1	6.9	14.8	0.0	74.2	0.45	0.4	11.6	3.5 - 10.3	0.72	-6.4	202.4	-7.9	4.5 - 9.3
FBRAN2	23.7	25.2	1.7	135.7	0.44	12.4	19.6	17.8 - 29.5	0.85	-0.7	407.9	-16.5	20.7 - 26.6
FBRAN3	10.9	11.8	1.0	52.8	0.52	5.3	9.8	8.4 - 13.5	0.78	0.3	161.6	-6.2	9.2 - 12.6
FFOLI	39.2	49.1	2.5	268.8	0.50	16.1	40.6	28.4 - 49.9	0.89	-9.5	789.2	-31.5	34.1 - 44.2
FTOTAL	242.0	322.9	16.0	1570.6	0.95	39.3	362.4	220.3 - 263.7	0.98	-15.7	2379.2	-56.8	226.7 - 257.3
FDEAD	2.0	2.9	0.1	14.3	0.27	1.0	1.8	1.2 - 2.8	0.73	-0.7	49.0	-2.1	1.5 - 2.5

NOTE. D - Diameter at breast height in metres
H - Height in metres
V - Volume inside bark in cubic metres

BRITISH COLUMBIA TREE BIOMASS REGRESSION ANALYSIS

03 WESTERN RED CEDAR
(70 TREES)

	DBH(cm)	HEIGHT(m)	AGE(yrs)
MAXIMUM	68 9	40 0	273
MEAN	21 7	13 6	74
MEDIAN	17 0	12 0	56
MINIMUM	3 8	3.4	18

COM-PONENT	MEAN	S.D.	MIN	MAX	y = a + bDDH RSQ	a	b	95% CONFIDENCE INTERVAL FOR THE MEAN	y = a + bV + cDD RSQ	a	b	c	95% CONFIDENCE INTERVAL FOR THE MEAN
DWOOD	127 9	239 8	1.0	1387 6	0 95	17 5	68 4	115 9 - 140 0	0 97	27 5	418 0	-1159 7	118 9 - 137 0
DBARK	17 8	33 5	0 2	181.9	0 83	3 3	9 0	14 6 - 21 0	0 86	4 0	51 2	-122 0	14 8 - 20 8
DBRAN1	11 7	33 6	0.0	195 5	0 40	1 6	6 3	5 7 - 17 8	0 76	-14 9	-75 5	806.0	7 9 - 15 6
DBRAN2	16 1	23 3	0 1	149 6	0 66	7 1	5 5	12 9 - 19 3	0 80	0 0	-19 0	330.2	13 7 - 18 6
DBRAN3	4 9	7 3	0 1	32.4	0 20	3 3	1 0	3 4 - 6.5	0 41	0 7	-12 2	130.1	3 6 - 6.3
DFOLI	18 5	29 2	0 9	157.9	0 62	7 6	6 7	14 2 - 22 7	0 84	-4 0	-42 4	354 6	15 8 - 21.2
DTOTAL	196 3	335 6	2 5	1732 1	0 97	40 4	96 9	183 8 - 208 7	0 99	13 3	320 3	539 0	187 5 - 205 1
FWOOD	243 2	431 2	1 6	2418 3	0 96	44 4	123 2	222 4 - 264 0	0 97	55 8	709 9	-1771 5	227 0 - 259 5
FBARK	36 5	64 6	0 3	384 7	0 90	7 6	17 9	31 7 - 41 3	0 93	11 1	115 5	-356 7	32 4 - 40 6
FBRAN1	19 6	55 0	0 0	325 3	0 41	3 0	10 3	9 7 - 29 6	0 76	-23 8	-122 7	1334 9	13 3 - 26 0
FBRAN2	29 7	41 9	0 1	259 1	0 72	12 9	10 4	24 6 - 34 9	0 85	0 2	-30 6	589 7	26 0 - 33 5
FBRAN3	12 2	18 8	0 4	90 6	0 19	8 2	2 4	8 2 - 16 1	0 34	2 3	-25 6	291 6	8 6 - 15 7
FFOLI	40 9	68 1	0 7	370 8	0 67	14 5	16 3	31 7 - 50 1	0 85	-10 2	-79 9	1181 1	34 8 - 47 0
FTOTAL	381 0	625 2	4 6	3192 2	0 98	90 5	100 7	358 3 - 403 7	0 99	35 4	566 7	1269 1	365 8 - 396 2
FDEAD	5 3	13 7	0 1	88 8	0 63	0 1	3 2	3 3 - 7 2	0 73	3 1	35 9	-205 0	3 6 - 7 0

NOTE D - Diameter at breast height in metres
H - Height in metres
V - Volume inside bark in cubic metres

BRITISH COLUMBIA TREE BIOMASS REGRESSION ANALYSIS

		DBH(cm)	HEIGHT(m)	AGE(yrs)
04 INTERIOR DOUGLAS FIR (41 TREES)	MAXIMUM	60 2	34 5	254
	MEAN	25 7	16 3	90
	MEDIAN	18 7	15 9	89
	MINIMUM	3 1	2.6	15

COMPONENT	MEAN	S.D.	MIN.	MAX	y = a + bDDH RSQ	a	b	95% CONFIDENCE INTERVAL FOR THE MEAN	y = a + bV + cDD + dDDHV RSQ	a	b	c	d	95% CONFIDENCE INTERVAL FOR THE MEAN
DWOOD	247.6	314.2	0.5	1141.1	0 80	34 5	85.8	204 5 - 290.8	0 82	-15 2	91 3	2315 0	-4 7	206 9 - 288 3
DBARK	48.8	66.8	0.2	302.2	0.80	3 6	18.2	39 6 - 58 1	0 82	-2 5	-53.9	735.0	3 5	40 1 - 57 6
DBRAN1	29.1	51.3	0.0	202.1	0.56	-0 2	11 8	18 7 - 39.5	0 55	-3 3	-15.5	359.5	1.8	18 6 - 39 7
DBRAN2	26.7	36.6	0.1	187.0	0.31	10.9	6.4	17 4 - 36.0	0.54	-3 9	-85.7	901.9	-0.3	19.1 - 34 3
DBRAN3	15 0	25.4	0.4	133.0	0.45	1.9	5.3	9.2 - 20.7	0 65	-0 3	-99.1	628.9	4.3	10.4 - 19 6
DFOLI	26.1	30.5	1.0	121.2	0 40	11.1	6.0	18 9 - 33 3	0.74	-3 4	-79.5	860.0	-0.6	21 3 - 30.8
DTOTAL	393.3	477.0	2.5	1843.8	0.84	61.9	133 5	334 8 - 451.9	0 88	-28 5	-242 4	5800 3	4.1	343.4 - 443 3
FWOOD	409 2	508.3	1.3	1752 7	0.79	66 4	138 1	337 9 - 480.6	0 83	-33 5	-56 6	5219 6	-6 0	345.2 - 473 2
FBARK	98.8	124.5	1 1	447.8	0.74	17.4	32 8	79 4 - 118 2	0 60	-10 4	-26 0	1405.2	-2 3	81 6 - 116 1
FBRAN1	49 6	90 3	0 0	406 9	0.48	1.5	19 4	29 7 - 69 5	0 48	-8 5	-50 8	840 7	2 3	29 6 - 69 6
FBRAN2	53.8	92.4	0.3	549 5	0 16	24 0	12 0	28 0 - 79.7	0 31	-8 1	-127 3	1636.6	-3 4	30 3 - 77 4
FBRAN3	27 3	40 7	0.8	226 7	0 54	4 4	9 2	18 9 - 35.7	0 78	0 3	-169.1	1088 0	7 2	21 4 - 33 2
FFOLI	51 0	59 9	2.1	252.3	0.40	22 0	11 7	36.8 - 65.3	0 73	-6 8	-141.1	1618 6	-1 8	41.5 - 60 5
FTOTAL	669 8	820 4	5.7	2795 7	0.79	135.7	223 2	575 2 - 804.4	0 87	-67 0	-370 9	11809 0	-4 0	599 1 - 780 5
FDEAD	7 8	10.6	0.1	37 6	0.44	2.4	2 2	5 3 - 10.2	0 51	4 8	26 4	-151 9	0 2	5 5 - 10 0

NOTE D - Diameter at breast height in metres
H - Height in metres
V - Volume inside bark in cubic metres

BRITISH COLUMBIA TREE BIOMASS REGRESSION ANALYSIS

05 PONDEROSA PINE
(42 TREES)

	DBH(cm)	HEIGHT(m)	AGE(yrs)
MAXIMUM	62.5	40.8	176
MEAN	27.7	15.4	78
MEDIAN	23.0	14.4	74
MINIMUM	3.4	2.1	11

COM-PONENT	MEAN	S.D.	MIN.	MAX.	V = a + bDDH			95% CONFIDENCE INTERVAL FOR THE MEAN	V = a + bV + cDD				95% CONFIDENCE INTERVAL FOR THE MEAN
					RSQ	a	b		RSQ	a	b	c	
DWOOD	313.2	498.2	0.4	2791.7	0.92	-42.0	139.3	271.4 - 355.1	0.96	42.1	790.0	-2970.7	283.2 - 343.3
DBARK	48.4	61.3	0.5	236.0	0.93	4.6	17.2	43.5 - 53.3	0.94	-0.3	42.6	139.4	43.7 - 53.1
DBRAN1	42.7	62.7	0.0	297.4	0.46	10.7	12.5	28.7 - 36.6	0.63	-12.9	-41.4	810.4	31.1 - 54.2
DBRAN2	45.7	55.4	0.0	196.5	0.50	16.4	11.5	33.9 - 57.6	0.69	-5.5	-38.6	750.5	36.4 - 55.1
DBRAN3	0.5	1.4	0.0	8.6	0.00	0.4	0.0	0.1 - 0.9	0.00	0.3	-0.5	5.8	0.1 - 0.9
DFOLI	27.9	34.3	0.3	147.3	0.40	11.6	6.4	19.9 - 36.0	0.53	0.2	-18.9	392.9	20.8 - 35.0
DTOTAL	478.5	649.4	2.8	3243.3	0.98	1.6	187.0	450.7 - 506.3	0.98	23.9	733.1	-851.9	451.6 - 505.4
FWOOD	610.9	831.6	1.1	3979.8	0.98	-0.6	239.8	577.7 - 644.0	0.98	26.1	933.9	-1032.3	579.2 - 642.5
FBARK	101.1	112.5	2.3	413.2	0.93	20.4	31.6	92.3 - 109.9	0.97	2.0	44.1	621.3	94.8 - 107.4
FBRAN1	74.6	111.0	0.0	473.5	0.49	16.1	22.9	50.7 - 98.5	0.69	-28.1	-79.9	1522.1	55.8 - 93.4
FBRAN2	92.9	116.3	0.0	514.2	0.48	32.4	23.7	67.5 - 118.2	0.64	-9.8	-69.2	1446.4	71.7 - 114.0
FBRAN3	2.1	5.0	0.0	24.6	0.00	2.5	-0.1	0.6 - 3.6	0.00	2.6	-0.1	-3.1	0.6 - 3.7
FFOLI	58.4	77.5	1.0	405.3	0.34	24.3	13.4	39.3 - 77.5	0.46	-1.1	-45.2	874.0	41.2 - 75.6
FTOTAL	939.9	1154.2	8.2	4733.9	0.97	95.1	331.3	883.0 - 996.7	0.98	-8.4	783.5	3428.4	894.2 - 985.6
FDEAD	15.1	21.7	0.1	81.1	0.20	7.4	3.0	9.2 - 21.0	0.27	1.3	-11.3	208.1	9.5 - 20.7

NOTE: D - Diameter at breast height in metres
H - Height in metres
V - Volume inside bark in cubic metres

BRITISH COLUMBIA TREE BIOMASS REGRESSION ANALYSIS

06 WESTERN HEMLOCK
(70 TREES)

	DBH(cm)	HEIGHT(m)	AGE(yrs)
MAXIMUM	70.5	43.7	253
MEAN	19.4	13.9	64
MEDIAN	15.4	10.6	40
MINIMUM	3.1	3.5	11

COM-PONENT	MEAN	S.D.	MIN.	MAX.	V = a + bDDH				V = a + bV + cDHV + dDDV					
					RSQ	a	b	95% CONFIDENCE INTERVAL FOR THE MEAN	RSQ	a	b	c	d	95% CONFIDENCE INTERVAL FOR THE MEAN
DWOOD	194.5	495.0	0.8	2448.6	0.99	5.5	123.3	184.9 - 204.0	1.00	-14.7	499.6	-8.0	317.9	186.7 - 202.2
DBARK	27.4	66.6	0.1	308.0	0.92	3.0	16.0	22.9 - 31.9	0.95	-6.0	104.5	-0.8	-60.7	24.1 - 30.7
DBRAN1	10.0	28.4	0.0	171.5	0.67	1.0	5.8	6.2 - 13.8	0.85	-1.2	27.8	4.1	-263.1	7.4 - 12.5
DBRAN2	14.1	20.9	0.2	120.4	0.55	8.2	3.9	10.8 - 17.4	0.80	2.2	48.0	1.3	-154.5	11.9 - 16.3
DBRAN3	8.1	14.0	0.4	93.9	0.52	4.2	2.5	5.8 - 10.4	0.87	-0.1	33.1	1.4	-137.5	6.9 - 9.3
DFOLI	14.5	22.4	0.9	154.5	0.57	8.0	4.3	11.1 - 17.9	0.85	2.7	43.3	2.6	-220.9	12.5 - 16.5
DTOTAL	268.5	629.6	2.7	3105.1	0.98	29.8	155.8	247.7 - 289.4	0.99	-17.0	756.3	0.7	-518.7	254.5 - 282.9
FWOOD	389.1	984.5	1.5	4858.9	0.99	13.7	244.9	367.8 - 410.3	0.99	-20.9	944.2	-1.9	-94.1	369.6 - 408.5
FBARK	48.1	108.5	0.3	498.3	0.93	8.0	26.1	41.3 - 54.9	0.96	-6.2	168.8	-1.9	-58.5	43.2 - 53.0
FBRAN1	18.5	54.0	0.0	337.8	0.69	1.3	11.2	11.5 - 25.6	0.88	-1.9	45.9	8.4	-516.6	14.2 - 22.8
FBRAN2	25.5	37.2	0.3	216.4	0.55	14.8	7.0	19.6 - 31.3	0.80	4.9	80.5	2.9	-296.0	21.6 - 29.4
FBRAN3	17.4	31.1	0.4	218.5	0.48	9.1	5.4	12.1 - 22.7	0.84	0.5	66.7	4.0	-343.2	14.5 - 20.3
FFOLI	31.5	49.8	1.1	339.6	0.53	17.5	9.1	23.5 - 39.5	0.84	7.2	86.0	7.4	-561.3	26.9 - 36.1
FTOTAL	530.1	1229.0	3.9	6087.9	0.98	64.5	303.8	487.7 - 572.4	0.99	-16.2	1392.2	18.8	-1869.7	502.2 - 558.0
FDEAD	4.7	7.2	0.1	28.7	0.18	3.5	0.8	3.2 - 6.3	0.58	0.0	21.1	-0.7	0.6	3.7 - 5.8

NOTE: D - Diameter at breast height in metres
H - Height in metres
V - Volume inside bark in cubic metres

BRITISH COLUMBIA TREE BIOMASS REGRESSION ANALYSIS

07 WHITE SPRUCE
(105 TREES)

	DBH(cm)	HEIGHT(m)	AGE(yrs)
MAXIMUM	57 6	39 3	245
MEAN	18 5	13 6	74
MEDIAN	12 6	9 4	58
MINIMUM	3 6	2 2	14

COM-PONENT	MEAN	S D.	MIN	MAX.	V = a + bDDH			95% CONFIDENCE INTERVAL FOR THE MEAN	V = a + bV + cDD				95% CONFIDENCE INTERVAL FOR THE MEAN
					RSQ	a	b		RSQ	a	b	c	
DWOOD	157 4	271 3	0 9	1370 8	0 98	6 5	113 4	150 7 - 164 2	0 99	1 3	378 1	-5 4	151 1 - 163 7
DBARK	17 9	27 5	0 2	131 3	0 93	3 0	11 2	16 4 - 19 3	0 94	0 8	24 1	136 9	16 6 - 19 2
DBRAN1	6 7	15 0	0 0	100 5	0 58	0 3	4 8	4 8 - 8 6	0 73	-5 3	-23 9	415 2	5 2 - 8 2
DBRAN2	17 6	22 2	0 6	105 8	0 52	8 5	6 8	14 6 - 20 5	0 82	-2 3	-57 0	828 8	15 8 - 19 4
DBRAN3	9 7	15 3	0 3	71 7	0 42	4 1	4 2	7 5 - 12 0	0 64	-2 3	-33 2	491 5	8 0 - 11 5
DFOLI	18 6	23 2	0 9	113 1	0 44	9 9	6 5	15 3 - 21 9	0 68	-0 2	-52 8	775 7	16 1 - 21 1
DTOTAL	227 6	354 8	3 3	1601 5	0 96	32 2	146 9	214 6 - 240 6	0 98	-8 0	235 3	2642 6	217 9 - 237 3
FWOOD	285 5	474 8	2 2	2216 4	0 99	21 2	198 7	274 7 - 296 5	0 99	7 6	627 6	337 0	275 7 - 295 5
FBARK	35 2	54 4	0 5	326 3	0 88	6 4	21 6	31 6 - 38 7	0 89	4 9	68 8	31 8	31 7 - 38 6
FBRAN1	10 3	23 0	0 0	156 8	0 58	0 5	7 4	7 5 - 13 2	0 74	-8 0	-38 0	653 5	8 1 - 12 5
FBRAN2	28 4	36 2	0 9	156 5	0 54	13 4	11 3	23 7 - 33 1	0 79	-2 8	-81 4	1244 2	25 2 - 31 5
FBRAN3	17 2	25 1	0 5	119 6	0 43	7 9	7 0	13 6 - 20 8	0 68	-3 3	-59 2	862 6	14 5 - 19 9
FFOLI	33 8	40 1	1 6	196 4	0 43	18 9	11 2	28 0 - 39 6	0 67	1 3	-91 7	1350 9	29 4 - 38 2
FTOTAL	410 5	623 2	6 5	2678 3	0 96	68 3	257 2	385 9 - 435 0	0 97	-0 3	426 1	4480 0	390 8 - 430 1
FDEAD	4 9	8 6	0 1	51 9	0 38	1 9	2 3	3 6 - 6 2	0 48	-0 7	-11 5	198 4	3 7 - 6 1

NOTE: D - Diameter at breast height in metres
H - Height in metres
V - Volume inside bark in cubic metres

BRITISH COLUMBIA TREE BIOMASS REGRESSION ANALYSIS

		DBH(cm)	HEIGHT(m)	AGE(yrs)
08 ENGELMANN SPRUCE	MAXIMUM	57.6	40.8	253
(43 TREES)	MEAN	23.7	17.2	94
	MEDIAN	20.0	14.9	89
	MINIMUM	4.9	3.2	21

COM-PONENT	MEAN	S.D.	MIN.	MAX.	y = a + bDDH RSQ	a	b	95% CONFIDENCE INTERVAL FOR THE MEAN	y = a + bV + cDD RSQ	a	b	c	95% CONFIDENCE INTERVAL FOR THE MEAN
DWOOD	216.3	310.4	1.2	1594.4	0.99	5.0	112.5	206.3 - 226.4	0.99	13.4	459.5	-800.6	207.0 - 225.7
DBARK	21.9	26.1	0.2	130.1	0.95	4.5	9.3	20.1 - 23.7	0.95	2.1	23.5	79.3	20.3 - 23.6
DBRAN1	10.6	19.4	0.0	74.4	0.62	0.1	5.6	7.1 - 14.2	0.70	-6.3	-8.6	277.0	7.5 - 13.8
DBRAN2	22.0	23.5	0.1	99.3	0.57	9.7	6.5	17.4 - 26.6	0.69	1.0	-16.5	390.1	18.1 - 26.0
DBRAN3	11.4	12.3	0.5	48.2	0.24	7.0	2.3	8.1 - 14.6	0.52	0.2	-23.6	317.3	8.8 - 13.9
DFOLI	23.7	20.8	0.8	72.3	0.37	14.7	4.7	18.8 - 28.6	0.49	7.2	-18.4	348.5	19.3 - 28.1
DTOTAL	305.5	390.4	3.5	1956.1	0.98	41.0	140.9	288.3 - 322.6	0.98	17.6	415.9	611.5	289.3 - 321.7
FWOOD	391.1	536.8	2.9	2786.8	0.99	25.9	194.6	372.7 - 409.4	0.99	32.8	755.7	-1115.7	373.5 - 408.7
FBARK	49.0	54.2	1.2	247.8	0.94	13.0	19.2	45.0 - 53.0	0.95	10.1	58.8	62.2	45.2 - 52.8
FBRAN1	17.0	30.8	0.0	119.2	0.65	-0.1	9.1	11.6 - 22.5	0.71	-8.8	-7.0	404.2	12.0 - 22.0
FBRAN2	38.5	41.3	0.2	175.4	0.59	16.7	11.6	30.6 - 46.5	0.68	2.4	-23.1	670.3	31.6 - 45.5
FBRAN3	22.5	23.3	1.1	99.4	0.30	13.5	4.8	16.6 - 28.3	0.57	0.5	-42.5	632.8	17.9 - 27.0
FFOLI	47.3	40.5	1.7	136.0	0.44	28.5	10.0	38.3 - 56.4	0.53	15.3	-23.4	617.5	39.1 - 55.6
FTOTAL	565.4	694.2	8.1	3495.7	0.97	97.6	249.3	528.3 - 602.5	0.97	52.4	718.4	1271.2	530.1 - 600.7
FDEAD	6.5	10.6	0.1	47.3	0.48	1.4	2.7	4.2 - 8.8	0.63	-3.1	-11.3	219.7	4.6 - 8.5

NOTE D - Diameter at breast height in metres
H - Height in metres
V - Volume inside bark in cubic metres

BRITISH COLUMBIA TREE BIOMASS REGRESSION ANALYSIS

		DBH(cm)	HEIGHT(m)	AGE(yrs)
09 PACIFIC SILVER FIR	MAXIMUM	30.4	25.8	167
(45 TREES)	MEAN	15.5	11.0	55
	MEDIAN	14.6	10.8	44
	MINIMUM	4.5	3.1	22

COM-PONENT	MEAN	S.D.	MIN.	MAX.	y = a + bDDH RSQ	a	b	95% CONFIDENCE INTERVAL FOR THE MEAN	y = a + bV + cDD RSQ	a	b	c	95% CONFIDENCE INTERVAL FOR THE MEAN
DWOOD	52.0	63.2	2.0	303.5	0.96	1.4	122.9	48.4 - 55.6	0.97	5.4	419.5	-596.2	49.0 - 55.0
DBARK	7.4	8.1	0.3	34.2	0.94	1.0	15.6	6.9 - 8.0	0.94	0.3	36.1	59.0	6.9 - 8.0
DBRAN1	1.4	4.2	0.0	25.9	0.41	-0.8	5.4	0.4 - 2.3	0.40	-1.6	5.0	76.9	0.4 - 2.3
DBRAN2	9.3	8.5	0.3	38.7	0.53	4.1	12.4	7.6 - 11.0	0.75	-0.7	-30.6	513.4	8.1 - 10.5
DBRAN3	3.2	3.3	0.2	19.3	0.53	1.2	4.9	2.5 - 3.9	0.69	-0.5	-8.8	175.9	2.7 - 3.7
DFOLI	15.3	15.3	1.1	64.5	0.54	5.9	22.5	12.2 - 18.3	0.78	-3.3	-61.6	980.3	13.2 - 17.4
DTOTAL	88.4	94.4	4.8	393.7	0.96	12.8	183.6	83.0 - 93.7	0.97	-0.4	359.5	1209.2	83.2 - 93.5
FWOOD	126.0	140.0	5.1	619.4	0.98	13.1	274.4	119.9 - 132.0	0.98	-0.1	636.7	1032.3	120.2 - 131.7
FBARK	16.1	17.1	0.8	72.5	0.94	2.6	32.8	14.9 - 17.3	0.94	1.0	75.6	127.4	14.9 - 17.3
FBRAN1	2.8	8.5	0.0	53.8	0.38	-1.6	10.6	0.8 - 4.7	0.41	-4.1	-5.0	268.5	0.9 - 4.7
FBRAN2	18.1	17.7	0.5	86.4	0.50	7.7	25.1	14.4 - 21.7	0.74	-2.9	-71.7	1117.5	15.5 - 20.7
FBRAN3	6.6	6.9	0.4	39.8	0.50	2.6	9.7	5.2 - 8.0	0.69	-1.1	-23.0	394.1	5.5 - 7.7
FFOLI	31.6	31.5	1.9	133.7	0.51	13.0	45.3	25.2 - 38.0	0.79	-7.3	-143.3	2126.5	27.4 - 35.8
FTOTAL	201.2	206.7	8.8	789.7	0.94	37.5	397.9	186.6 - 215.7	0.97	-14.5	469.4	5066.3	190.6 - 211.7
FDEAD	1.2	1.5	0.1	8.0	0.06	0.8	0.9	0.8 - 1.7	0.16	0.2	-5.9	66.9	0.8 - 1.6

NOTE D - Diameter at breast height in metres
H - Height in metres
V - Volume inside bark in cubic metres

BRITISH COLUMBIA TREE BIOMASS REGRESSION ANALYSIS

		DBH(cm)	HEIGHT(m)	AGE(yrs)
10 GRAND FIR	MAXIMUM	43.9	34.8	228
(40 TREES)	MEAN	23.1	16.7	62
	MEDIAN	20.2	15.2	48
	MINIMUM	4.6	3.4	17

					y = a + bDDH				y = a + bV + cDD				
COM-PONENT	MEAN	S.D.	MIN.	MAX.	RSQ	a	b	95% CONFIDENCE INTERVAL FOR THE MEAN	RSQ	a	b	c	95% CONFIDENCE INTERVAL FOR THE MEAN
DWOOD	155.4	170.8	0.6	629.5	0.95	5.9	105.7	143.9 - 166.9	0.95	4.8	316.4	-54.1	143.6 - 167.2
DBARK	23.8	29.1	0.2	121.9	0.79	0.6	16.4	19.6 - 28.0	0.81	-7.2	10.8	384.1	19.9 - 27.8
DBRAN1	5.9	9.1	0.0	42.3	0.37	0.8	3.6	3.7 - 8.1	0.60	-4.4	-15.4	267.2	4.1 - 7.7
DBRAN2	16.9	12.3	1.3	49.0	0.53	8.7	5.8	14.3 - 19.5	0.53	7.7	6.3	110.2	14.3 - 19.5
DBRAN3	7.7	6.8	0.0	27.6	0.45	3.5	3.0	6.1 - 9.3	0.64	0.2	-10.3	193.5	6.4 - 9.0
DFOLI	28.3	28.4	0.6	137.4	0.46	10.7	12.4	21.9 - 34.8	0.64	-2.9	-37.0	757.4	23.1 - 33.6
DTOTAL	237.8	236.7	9.7	836.3	0.96	30.2	146.9	222.9 - 252.7	0.96	-1.7	270.9	1658.3	223.0 - 252.6
FWOOD	355.3	374.9	1.5	1542.6	0.97	23.9	234.5	336.4 - 374.2	0.98	18.0	698.1	-67.3	337.7 - 372.9
FBARK	54.9	64.3	1.1	272.6	0.73	5.4	35.0	44.6 - 65.2	0.76	-11.1	12.0	930.7	45.1 - 64.6
FBRAN1	10.6	16.8	0.0	80.1	0.35	1.4	6.5	6.4 - 14.7	0.59	-7.3	-29.7	501.4	7.2 - 13.9
FBRAN2	33.2	24.5	2.3	91.8	0.52	17.2	11.3	28.0 - 38.5	0.58	10.1	-4.6	392.1	28.3 - 38.2
FBRAN3	16.7	15.0	0.1	64.7	0.40	8.0	6.1	13.1 - 20.3	0.61	0.6	-24.4	433.7	13.8 - 19.6
FFOLI	60.6	59.8	1.2	282.2	0.45	24.3	25.7	46.8 - 74.4	0.66	-5.5	-89.7	1705.3	49.8 - 71.5
FTOTAL	531.2	512.4	20.3	1928.6	0.97	80.3	319.1	501.6 - 560.9	0.97	5.0	561.8	3895.9	504.7 - 557.8
FDEAD	7.0	10.0	0.1	55.1	0.21	2.6	3.1	4.2 - 9.7	0.17	2.7	9.0	-2.9	4.1 - 9.8

NOTE D - Diameter at breast height in metres
H - Height in metres
V - Volume inside bark in cubic metres

11 WESTERN LARCH
(41 TREES)

	DBH(cm)	HEIGHT(m)	AGE(yrs)
MAXIMUM	57 5	38 5	159
MEAN	24 2	19 8	71
MEDIAN	17 2	17 3	55
MINIMUM	3 1	2 9	11

COM-PONENT	MEAN	S.D	MIN	MAX.	V = a + bDDH			95% CONFIDENCE INTERVAL FOR THE MEAN	V = a + bV + cHV				95% CONFIDENCE INTERVAL FOR THE MEAN
					RSQ	a	b		RSQ	a	b	c	
DWOOD	282 1	340 5	0 8	1211 4	0 91	46 9	100 9	251 2 - 312 9	0 94	-9 8	883 7	-12 7	257 6 - 306 5
DBARK	37 3	49 0	0 2	178 9	0 97	2 4	15 0	34 7 - 39 8	0 97	1 3	54 2	0 2	34 7 - 39 8
DBRAN1	11 5	26 4	0 0	110 1	0 09	5 1	2 7	3 8 - 19 2	0 39	-8 1	149 0	-3 7	5 2 - 17 8
DBRAN2	17 9	27 9	0 0	124 9	0 14	9 8	3 5	10 0 - 25 8	0 52	-5 8	175 9	-4 4	12 0 - 23 8
DBRAN3	9 1	11 1	0 0	43 3	0 18	5 5	1 5	6 0 - 12 1	0 64	-1 3	76 3	-1 9	7 0 - 11 1
DFOLI	7 8	10 0	0 2	37 7	0 19	4 5	1 4	5 1 - 10 6	0 47	-0 3	55 9	-1 4	5 6 - 10 1
DTOTAL	365 7	430 1	2 4	1468 7	0 88	74 1	125 1	319 6 - 411 8	0 94	-24 0	1395 0	-23 8	332 3 - 399 0
FWOOD	462 6	547 2	1 6	1957 5	0 90	86 5	161 4	410 4 - 514 8	0 94	-14 5	1523 8	-23 2	422 4 - 502 8
FBARK	84 8	98 4	1 3	345 7	0 96	15 2	29 9	78 6 - 91 0	0 97	3 7	208 2	-2 3	79 5 - 90 1
FBRAN1	20 2	47 1	0 0	214 4	0 09	8 9	4 8	6 5 - 34 0	0 37	-14 0	259 4	-6 5	8 8 - 31 7
FBRAN2	38 9	53 7	0 5	213 7	0 19	21 0	7 7	24 2 - 53 7	0 69	-12 9	383 4	-9 6	29 7 - 48 1
FBRAN3	19 7	21 7	1 1	81 0	0 19	12 6	3 1	13 7 - 25 7	0 66	-0 9	151 4	-3 8	15 8 - 23 6
FFOLI	17 1	20 0	0 4	70 4	0 23	9 8	3 1	11 7 - 22 4	0 49	0 5	108 1	-2 6	12 7 - 21 4
FTOTAL	643 4	729 9	6 6	2458 3	0 86	154 1	210 0	559 0 - 727 8	0 94	-38 2	2634 3	-48 0	586 6 - 700 2
FDEAD	1 2	2 2	0 1	10 5	0 06	0 7	0 2	0 5 - 1 8	0 37	-0 4	12 6	-0 3	0 6 - 1 7

NOTE D - Diameter at breast height in metres
H - Height in metres
V - Volume inside bark in cubic metres

BRITISH COLUMBIA TREE BIOMASS REGRESSION ANALYSIS

12 WESTERN WHITE PINE
(40 TREES)

	DBH(cm)	HEIGHT(m)	AGE(yrs)
MAXIMUM	52.4	37.8	175
MEAN	18.7	13.5	51
MEDIAN	18.4	11.2	33
MINIMUM	3.7	2.5	16

COM-PONENT	MEAN	S.D.	MIN.	MAX.	V = a + bDDH			95% CONFIDENCE INTERVAL FOR THE MEAN	V = a + bV + cDD				95% CONFIDENCE INTERVAL FOR THE MEAN
					RSQ	a	b		RSQ	a	b	c	
DWOOD	124.1	208.8	0.7	1029.9	0.99	2.3	120.4	118.4 - 129.8	0.99	-1.0	399.2	-151.1	118.2 - 130.0
DBARK	12.5	19.7	0.1	95.8	0.96	1.2	11.2	11.3 - 13.7	0.96	-0.2	29.7	61.0	11.3 - 13.7
DBRAN1	6.9	16.0	0.0	67.5	0.44	0.6	6.2	3.2 - 10.7	0.57	-6.3	-24.9	457.5	3.7 - 10.2
DBRAN2	15.0	23.0	0.2	131.1	0.23	8.3	6.6	8.7 - 21.3	0.36	-1.2	-39.5	623.9	9.3 - 20.7
DBRAN3	4.6	7.7	0.1	33.1	0.80	0.6	4.0	3.5 - 5.7	0.81	-0.5	6.7	61.7	3.6 - 5.6
DFOLI	13.8	16.5	0.3	60.7	0.37	7.8	6.0	9.8 - 17.8	0.60	-1.0	-36.9	575.3	10.6 - 17.0
DTOTAL	176.9	271.7	2.0	1303.3	0.96	20.8	154.4	160.5 - 193.4	0.97	-10.3	334.2	1628.2	162.4 - 191.5
FWOOD	249.1	379.4	1.4	1789.9	0.98	28.5	218.0	234.4 - 263.8	0.99	-0.8	569.8	1301.3	237.1 - 261.1
FBARK	37.4	49.0	1.0	220.5	0.92	9.9	27.2	33.0 - 41.8	0.94	2.2	45.4	428.8	33.7 - 41.2
FBRAN1	11.5	25.1	0.0	107.5	0.36	2.5	8.9	5.2 - 17.7	0.54	-9.9	-51.7	819.0	6.2 - 16.8
FBRAN2	29.6	40.9	0.8	226.3	0.22	17.7	11.7	18.4 - 40.8	0.40	-1.8	-87.5	1285.2	19.8 - 39.4
FBRAN3	10.5	15.7	0.2	59.2	0.72	2.7	7.7	7.9 - 13.1	0.74	0.0	9.3	158.7	8.0 - 13.0
FFOLI	31.8	37.5	0.8	139.3	0.29	19.6	12.1	22.1 - 41.6	0.56	-2.1	-100.2	1428.4	24.2 - 39.5
FTOTAL	369.9	507.9	5.6	2294.4	0.94	80.9	285.6	332.0 - 407.8	0.97	-12.4	385.1	5421.4	342.3 - 397.6
FDEAD	3.7	7.2	0.1	31.7	0.31	1.3	2.4	1.9 - 5.6	0.39	-1.3	-8.8	168.3	2.0 - 5.5

NOTE. D - Diameter at breast height in metres
H - Height in metres
V - Volume inside bark in cubic metres

BRITISH COLUMBIA TREE BIOMASS REGRESSION ANALYSIS

13 LODGEPOLE PINE
(98 TREES)

	DBH(cm)	HEIGHT(m)	AGE(yrs)
MAXIMUM	48 9	39 6	242
MEAN	18 8	15 5	70
MEDIAN	18 2	16 4	62
MINIMUM	3 3	2 3	10

COM-PONENT	MEAN	S D	MIN	MAX	V = a + bDDH RSQ	a	b	95% CONFIDENCE INTERVAL FOR THE MEAN	V = a + bV + cDD RSQ	a	b	c	95% CONFIDENCE INTERVAL FOR THE MEAN
DWOOD	164 4	195 9	0 7	1079 1	0 95	18 3	135 4	155 5 - 173 3	0 96	-6 4	239 7	1742 3	156 9 - 171 9
DBARK	13 0	13 5	0 2	70 6	0 90	3 2	9 1	12 2 - 13 9	0 93	0 7	10 1	182 4	12 3 - 13 7
DBRAN1	4 2	6 9	0 0	35 2	0 42	0 8	3 2	3 2 - 5 3	0 62	-2 5	-16 2	273 5	3 4 - 5 1
DBRAN2	13 8	16 0	0 0	99 5	0 42	5 8	7 4	11 4 - 16 2	0 67	-2 7	-43 3	698 7	12 0 - 15 6
DBRAN3	3 0	4 0	0 0	19 2	0 35	1 2	1 7	2 4 - 3 7	0 53	-0 7	-9 3	153 7	2 5 - 3 6
DFOLI	9 8	11 2	0 3	55 2	0 24	5 5	4 0	7 9 - 11 8	0 58	-1 3	-41 5	569 2	8 4 - 11 3
DTOTAL	208 3	234 9	2 0	1205 8	0 93	34 7	160 8	195 9 - 220 7	0 96	-12 9	139 5	7619 7	199 5 - 217 1
FWOOD	290 6	330 7	1 5	1726 8	0 93	45 5	227 1	273 9 - 307 3	0 96	-12 2	273 5	4297 3	277 9 - 303 3
FBARK	27 9	26 8	0 7	119 6	0 76	9 8	16 6	25 2 - 30 4	0 85	1 2	-14 5	685 3	25 7 - 29 8
FBRAN1	8 0	13 4	0 0	66 9	0 40	1 4	6 0	5 9 - 10 0	0 57	-4 6	-28 9	499 3	6 2 - 9 7
FBRAN2	25 6	27 4	0 3	165 4	0 39	12 4	12 2	21 4 - 29 9	0 69	-3 5	-86 9	1317 9	22 6 - 28 6
FBRAN3	5 9	7 3	0 1	40 0	0 36	2 4	3 1	4 7 - 7 0	0 54	-1 0	-17 2	282 2	4 8 - 6 8
FFOLI	18 8	19 8	0 9	95 3	0 26	11 0	7 2	15 4 - 22 2	0 59	-1 1	-73 1	1011 0	16 3 - 21 3
FTOTAL	376 6	403 2	4 8	1923 4	0 90	82 6	272 3	351 8 - 401 3	0 96	-21 3	52 9	8092 9	360 9 - 392 2
FDEAD	5 0	6 0	0 1	31 6	0 18	3 0	1 9	3 9 - 6 1	0 30	0 7	-12 7	194 4	4 0 - 6 0

NOTE D - Diameter at breast height in metres
H - Height in metres
V - Volume inside bark in cubic metres

BRITISH COLUMBIA TREE BIOMASS REGRESSION ANALYSIS

14 MOUNTAIN HEMLOCK
(39 TREES)

	DBH(cm)	HEIGHT(m)	AGE(yrs)
MAXIMUM	44.0	25.3	224
MEAN	20.0	10.5	108
MEDIAN	17.1	8.5	94
MINIMUM	8.9	4.0	54

COM-PONENT	MEAN	S.D.	MIN.	MAX.	y = a + bDDH				y = a + bV + cDHV + dDDV					
					RSQ	a	b	95% CONFIDENCE INTERVAL FOR THE MEAN	RSQ	a	b	c	d	95% CONFIDENCE INTERVAL FOR THE MEAN
DWOOD	120.1	190.2	6.1	779.4	0.99	5.4	145.0	113.3 - 126.8	0.99	3.3	465.9	38.6	-1998.1	114.3 - 125.8
DBARK	22.6	36.6	1.9	141.7	0.95	0.9	27.4	20.0 - 25.1	0.97	-1.0	107.8	-22.7	1159.5	20.7 - 24.4
DBRAN1	4.0	9.0	0.0	34.4	0.85	-1.1	6.4	2.8 - 5.1	0.94	0.6	-4.3	-7.7	561.7	3.3 - 4.6
DBRAN2	9.5	12.3	1.3	67.0	0.70	3.2	7.9	7.4 - 11.6	0.73	5.0	0.3	9.2	-360.9	7.5 - 11.5
DBRAN3	4.6	4.8	0.0	18.3	0.69	2.1	3.1	3.7 - 5.4	0.72	1.7	15.3	-3.9	187.4	3.8 - 5.4
DFOLI	11.3	14.8	0.2	64.0	0.63	4.1	9.1	8.4 - 14.1	0.74	1.8	57.1	-19.3	914.5	8.9 - 13.6
DTOTAL	171.9	259.9	14.4	1019.0	0.99	14.6	198.9	166.0 - 177.7	0.99	11.5	642.2	-5.9	464.1	165.7 - 178.1
FWOOD	206.9	319.1	10.8	1245.9	0.99	14.1	243.9	198.5 - 215.3	1.00	6.4	841.0	53.4	-3041.8	200.6 - 213.2
FBARK	34.5	51.7	3.0	200.2	0.96	3.7	39.0	31.4 - 37.5	0.98	1.1	152.2	-27.2	1378.2	32.2 - 36.7
FBRAN1	6.4	14.5	0.0	57.8	0.84	-1.7	10.2	4.5 - 8.2	0.93	1.1	-6.4	-11.8	866.2	5.2 - 7.6
FBRAN2	16.3	20.3	2.1	108.3	0.72	5.8	13.3	12.9 - 19.7	0.74	8.3	6.1	13.1	-512.4	13.1 - 19.6
FBRAN3	10.5	14.3	1.6	79.8	0.22	6.4	5.3	6.6 - 14.6	0.26	2.0	75.0	-9.0	187.0	6.8 - 14.5
FFOLI	21.2	27.0	0.4	113.8	0.58	8.6	15.9	15.7 - 26.7	0.68	4.5	103.6	-35.4	1670.8	16.4 - 26.0
FTOTAL	295.9	429.2	24.8	1629.1	0.99	36.8	327.6	282.1 - 309.6	0.99	23.3	1171.5	-16.8	547.9	281.7 - 310.0
FDEAD	0.9	0.9	0.1	3.1	0.68	0.5	0.5	0.7 - 1.0	0.82	0.1	6.6	-0.4	-4.7	0.8 - 1.0

NOTE. D - Diameter at breast height in metres
H - Height in metres
V - Volume inside bark in cubic metres

BRITISH COLUMBIA TREE BIOMASS REGRESSION ANALYSIS

15 BLACK SPRUCE
(60 TREES)

	DBH(cm)	HEIGHT(m)	AGE(yrs)
MAXIMUM	38 4	30 1	222
MEAN	16 5	14 0	119
MEDIAN	16 1	13 8	122
MINIMUM	3 5	2 9	47

COM-PONENT	MEAN	S.D.	MIN.	MAX.	y = a + bDDH RSQ	a	b	95% CONFIDENCE INTERVAL FOR THE MEAN	y = a + bV + cDD + dDDV RSQ	a	b	c	d	95% CONFIDENCE INTERVAL FOR THE MEAN
DWOOD	69 1	70 6	0 0	484 4	0 94	13 4	107 0	64 6 - 73 7	0 96	10 7	796 9	-2097 6	-1617 0	65 5 - 72 8
DBARK	9 9	10 3	0 0	71 8	0 96	1 7	15 8	9 4 - 10 4	0 96	1 3	67 0	-83 6	-53 8	9 4 - 10 4
DBRAN1	0 9	4 3	0 0	32 2	0 21	-0 7	3 2	0 0 - 1 9	0 42	-2 7	-82 2	493 0	266 5	0 1 - 1 7
DBRAN2	9 5	10 1	0 0	45 8	0 56	3 3	12 0	7 8 - 11 2	0 77	-3 1	-133 8	1032 5	399 1	8 3 - 10 8
DBRAN3	5 6	7 0	0 0	37 8	0 57	1 2	8 3	4 4 - 6 8	0 73	-1 5	-105 7	700 7	289 9	4 7 - 6 5
DFOLI	10 4	13 0	0 0	74 5	0 41	3 4	13 3	7 8 - 12 9	0 68	-3 8	-251 5	1614 0	814 3	8 5 - 12 2
DTOTAL	105 4	103 4	2 5	697 5	0 97	22 4	159 5	100 9 - 109 9	0 98	0 9	290 9	1661 0	199 0	101 8 - 109 0
FWOOD	121 4	134 8	0 0	971 0	0 96	13 5	207 3	115 0 - 127 9	0 97	22 2	1064 1	-2550 3	-814 0	115 6 - 127 3
FBARK	17 9	17 1	0 5	120 6	0 97	4 1	26 4	17 1 - 18 6	0 97	3 0	94 6	-43 3	-40 7	17 1 - 18 6
FBRAN1	1 6	6 2	0 0	46 5	0 21	-0 9	4 7	0 2 - 3 0	0 42	-4 1	-112 0	702 6	346 5	0 4 - 2 8
FBRAN2	14 4	15 1	0 5	68 1	0 55	5 2	17 7	11 9 - 17 0	0 77	-4 5	-211 5	1602 5	628 5	12 6 - 16 3
FBRAN3	10 3	11 2	0 6	60 9	0 56	3 1	13 3	8 1 - 11 9	0 71	-1 8	-151 1	1059 1	539 6	8 5 - 11 5
FFOLI	18 4	20 6	1 7	120 1	0 42	7 3	21 2	14 4 - 22 3	0 67	-5 1	-366 8	2458 6	1140 3	15 4 - 21 3
FTOTAL	183 6	188 5	5 1	1309 5	0 97	32 4	290 5	175 1 - 192 2	0 97	9 8	317 4	3229 2	1800 2	175 8 - 191 5
FDEAD	3 0	2 4	0 1	9 4	0 18	2 1	1 6	2 4 - 3 5	0 45	0 0	14 5	51 7	-116 4	2 5 - 3 4

NOTE D - Diameter at breast height in metres
H - Height in metres
V - Volume inside bark in cubic metres

BRITISH COLUMBIA TREE BIOMASS REGRESSION ANALYSIS

16 SUBALPINE FIR (89 TREES)

	DBH(cm)	HEIGHT(m)	AGE(yrs)
MAXIMUM	44.4	27.9	201
MEAN	16.2	10.8	74
MEDIAN	12.9	8.4	60
MINIMUM	3.5	2.2	13

COM-PONENT	MEAN	S.D.	MIN.	MAX.	y = a + bDBH RSQ	a	b	95% CONFIDENCE INTERVAL FOR THE MEAN	y = a + bV + cDD + dD RSQ	a	b	c	d	95% CONFIDENCE INTERVAL FOR THE MEAN
DWOOD	72.6	111.8	0.6	508.9	0.99	4.0	107.4	69.8 - 75.5	0.99	-6.3	385.4	-705.7	137.3	70.1 - 75.2
DBARK	12.0	18.3	0.2	83.6	0.94	1.0	17.2	11.0 - 12.9	0.94	1.3	30.7	253.4	-29.6	11.0 - 12.9
DBRAN1	6.1	17.9	0.0	135.6	0.58	-2.4	13.2	3.7 - 8.5	0.79	19.9	-122.2	2239.7	-419.8	4.4 - 7.8
DBRAN2	16.6	23.5	0.3	134.3	0.78	3.7	20.1	14.3 - 18.9	0.91	12.4	-125.2	2161.8	-283.5	15.1 - 18.0
DBRAN3	9.2	16.2	0.2	113.6	0.47	2.3	10.9	6.8 - 11.6	0.62	5.4	-99.5	1457.5	-163.4	7.1 - 11.3
DFOLI	16.9	24.1	0.5	175.3	0.56	5.7	17.5	13.6 - 20.2	0.75	15.2	-175.1	2614.1	-332.6	14.4 - 19.4
DTOTAL	133.4	197.7	2.5	1104.6	0.95	14.3	186.2	123.9 - 142.8	0.97	47.8	-106.0	8040.9	-1093.6	126.4 - 140.3
FWOOD	150.1	226.1	1.5	1063.1	0.98	11.4	217.0	144.0 - 156.2	0.99	-4.3	590.6	636.5	40.3	144.5 - 155.7
FBARK	24.7	33.7	0.5	143.5	0.97	4.2	32.0	23.5 - 26.0	0.98	-3.5	94.1	-115.1	75.9	23.6 - 25.8
FBRAN1	10.8	32.3	0.0	241.2	0.39	-4.5	24.0	6.5 - 15.1	0.81	37.2	-217.1	4087.7	-773.3	7.9 - 13.8
FBRAN2	30.9	44.6	0.5	279.0	0.77	6.7	37.9	26.4 - 35.3	0.91	27.1	-250.3	4331.4	-597.2	28.1 - 33.7
FBRAN3	18.2	31.6	0.4	224.4	0.49	4.5	21.4	13.5 - 22.9	0.63	11.1	-194.0	2862.2	-328.7	14.2 - 22.2
FFOLI	33.7	48.1	0.9	362.8	0.56	11.4	34.9	27.0 - 40.3	0.75	32.4	-362.6	5399.1	-699.6	28.7 - 38.6
FTOTAL	268.4	390.9	4.8	2226.4	0.94	33.6	367.2	248.8 - 287.9	0.97	99.9	-339.3	17202.0	-2282.7	254.7 - 282.1
FDEAD	5.7	11.1	0.1	54.2	0.53	0.6	7.9	4.1 - 7.3	0.68	-1.9	120.7	-1120.4	152.3	4.4 - 7.0

NOTE: D - Diameter at breast height in metres
H - Height in metres
V - Volume inside bark in cubic metres

BRITISH COLUMBIA TREE BIOMASS REGRESSION ANALYSIS

17 YELLOW CEDAR
(41 TREES)

	DBH(cm)	HEIGHT(m)	AGE(yrs)
MAXIMUM	42.4	30.2	214
MEAN	17.7	11.3	72
MEDIAN	14.6	9.6	54
MINIMUM	8.2	5.2	25

						$V = a + bDDH$				$V = a + bV + cDD$				
COM-PONENT	MEAN	S.D	MIN	MAX	RSQ	a	b	95% CONFIDENCE INTERVAL FOR THE MEAN	RSQ	a	b	c		95% CONFIDENCE INTERVAL FOR THE MEAN
DWOOD	107.2	201.8	8.1	931.5	0.98	-4.0	166.2	97.7 - 116.8	0.98	4.1	639.1	-1093.7		97.5 - 116.9
DBARK	8.3	12.1	0.8	60.9	0.91	1.8	9.6	7.2 - 9.3	0.92	-0.2	19.0	109.4		7.2 - 9.3
DBRAN1	2.3	4.8	0.0	25.0	0.67	0.1	3.3	1.5 - 3.2	0.70	-1.3	0.5	91.3		1.5 - 3.1
DBRAN2	7.7	8.1	0.5	32.2	0.63	4.0	5.4	6.2 - 9.2	0.70	0.8	-4.7	209.2		6.3 - 9.0
DBRAN3	1.8	1.7	0.2	6.6	0.50	1.2	1.0	1.5 - 2.2	0.72	0.1	-4.7	74.8		1.6 - 2.1
DFOLI	10.4	9.4	1.4	40.2	0.59	6.2	6.1	8.6 - 12.3	0.67	2.2	-9.0	269.5		8.8 - 12.1
DTOTAL	137.5	231.5	12.1	1088.7	0.99	9.2	191.6	129.0 - 146.1	0.98	5.7	640.7	-339.4		128.4 - 146.7
FWOOD	170.6	305.1	11.6	1416.2	0.98	2.1	251.6	156.6 - 184.5	0.97	4.8	894.1	-943.3		155.8 - 185.4
FBARK	17.2	22.5	2.1	110.4	0.93	5.1	18.1	15.4 - 19.1	0.95	-0.2	23.9	310.0		15.7 - 18.8
FBRAN1	3.9	8.3	0.0	44.3	0.68	0.1	5.8	2.5 - 5.4	0.69	-2.1	3.8	132.9		2.5 - 5.3
FBRAN2	13.5	13.7	1.3	53.4	0.60	7.5	8.9	10.8 - 16.1	0.70	1.3	-14.0	394.2		11.2 - 15.8
FBRAN3	3.4	3.0	0.4	12.4	0.46	2.3	1.7	2.8 - 4.1	0.69	0.2	-9.3	137.2		2.9 - 3.9
FFOLI	19.6	17.0	2.7	69.8	0.54	12.5	10.5	16.0 - 23.1	0.63	4.7	-21.0	504.0		16.4 - 22.7
FTOTAL	228.2	358.7	19.5	1693.8	0.98	29.6	296.5	213.9 - 242.6	0.98	8.6	877.6	534.9		213.1 - 243.4
FDEAD	1.2	1.9	0.1	8.3	0.68	0.3	1.3	0.9 - 1.6	0.70	-0.1	1.5	25.3		0.9 - 1.5

NOTE D = Diameter at breast height in metres
H = Height in metres
V = Volume inside bark in cubic metres

BRITISH COLUMBIA TREE BIOMASS REGRESSION ANALYSIS

		DBH(cm)	HEIGHT(m)	AGE(yrs)
18 BLACK COTTONWOOD	MAXIMUM	31.5	25.4	45
(40 TREES)	MEAN	16.2	13.8	19
	MEDIAN	13.9	12.8	16
	MINIMUM	5.6	6.9	8

					y = a + bDDH				y = a + bV + cDD				
COM-PONENT	MEAN	S.D.	MIN.	MAX.	RSQ	a	b	95% CONFIDENCE INTERVAL FOR THE MEAN	RSQ	a	b	c	95% CONFIDENCE INTERVAL FOR THE MEAN
DWOOD	57.0	68.6	5.2	261.5	0.92	2.3	97.5	50.9 - 63.2	0.94	9.1	488.7	-860.7	51.8 - 62.3
DBARK	10.0	11.5	1.1	46.1	0.83	1.2	15.5	8.5 - 11.4	0.84	1.9	69.2	-80.8	8.6 - 11.4
DBRAN1	4.4	7.8	0.0	26.4	0.82	-1.5	10.5	3.4 - 5.4	0.82	-2.8	11.6	169.1	3.4 - 5.4
DBRAN2	17.4	20.6	1.6	95.7	0.66	3.4	25.0	13.7 - 21.1	0.79	-6.3	-100.5	1231.2	14.5 - 20.3
DBRAN3	1.3	1.5	0.1	8.9	0.33	0.6	1.3	0.9 - 1.7	0.43	-0.1	-7.6	80.3	0.9 - 1.7
DFOLI	5.1	5.9	0.5	26.3	0.55	1.5	6.5	3.9 - 6.4	0.56	0.2	-0.4	156.6	3.9 - 6.4
DTOTAL	95.3	108.0	9.9	383.4	0.95	7.4	156.4	88.0 - 102.6	0.95	2.0	460.9	699.6	88.0 - 102.5
FWOOD	117.8	138.7	10.5	528.7	0.94	5.9	199.2	106.9 - 128.6	0.95	11.3	831.8	-685.2	107.9 - 127.6
FBARK	22.3	23.2	2.9	90.2	0.88	4.1	32.4	19.9 - 24.8	0.89	4.2	119.6	-10.1	19.9 - 24.7
FBRAN1	8.0	14.2	0.0	49.6	0.82	-2.7	19.0	6.1 - 9.9	0.82	-5.2	18.8	322.6	6.1 - 9.9
FBRAN2	31.6	38.1	3.0	182.6	0.67	5.5	46.4	24.8 - 38.4	0.79	-11.9	-175.9	2215.1	26.2 - 37.0
FBRAN3	2.4	2.7	0.1	12.6	0.38	1.0	2.5	1.8 - 3.1	0.46	0.0	-11.3	131.3	1.8 - 3.0
FFOLI	9.7	11.5	0.6	48.6	0.58	2.3	13.1	7.4 - 12.0	0.58	0.9	19.9	180.3	7.4 - 12.0
FTOTAL	191.8	215.6	20.9	763.8	0.96	16.2	312.7	177.7 - 205.8	0.96	-0.7	803.1	2153.9	177.9 - 205.7
FDEAD	1.8	2.3	0.1	8.3	0.38	0.6	2.2	1.3 - 2.4	0.38	0.8	10.7	-18.1	1.3 - 2.4

NOTE: D - Diameter at breast height in metres
H - Height in metres
V - Volume inside bark in cubic metres

BRITISH COLUMBIA TREE BIOMASS REGRESSION ANALYSIS

19 RED ALDER
(41 TREES)

	DBH(cm)	HEIGHT(m)	AGE(yrs)
MAXIMUM	33 3	23 8	48
MEAN	13 2	11 5	19
MEDIAN	11 5	10 9	16
MINIMUM	5.8	6.1	5

COM-PONENT	MEAN	S.D	MIN	MAX	y = a + bDDH RSQ	a	b	95% CONFIDENCE INTERVAL FOR THE MEAN	y = a + bV + cDD RSQ	a	b	c	95% CONFIDENCE INTERVAL FOR THE MEAN
DWOOD	42 5	75 8	3.7	425 0	1.00	-4 6	159 7	40 9 - 44.1	1.00	0 6	569 4	-774 1	41.4 - 43 5
DBARK	5 9	11 4	0 5	63 9	0.98	-1 2	24 0	5 4 - 6.3	0.99	0 2	95.3	-195 5	5.5 - 6 2
DBRAN1	4 1	7 7	0.0	37 8	0 35	1 2	9 9	2 2 - 6 0	0 73	-6.7	-94 7	999 7	2.9 - 5.3
DBRAN2	8 7	7.8	0 8	34.6	0.31	5.9	9 5	6 7 - 10.7	0.73	-2 5	-104 5	1070 4	7 5 - 10.0
DBRAN3	1 6	1 7	0.1	6.1	0 35	1 0	2 1	1 2 - 2.0	0 76	-0 8	-21.1	221.3	1.3 - 1.8
DFOLI	2 9	2 8	0.2	14 3	0.02	2.5	1 3	2 0 - 3.7	0 65	-1.2	-53.9	466.4	2.3 - 3.4
DTOTAL	65 6	98 5	5.4	536.3	0 99	4.8	206 5	62 0 - 69.2	0 99	-10 3	390 6	1788.2	62 7 - 68 4
FWOOD	80 9	139 8	6 4	777 5	1 00	-5 9	294 6	78 7 - 83.1	1 00	-0 3	988.3	-923 2	79 1 - 82 7
FBARK	11 6	19 6	1 0	109 0	0 99	-0 5	41 2	11 1 - 12.1	1.00	0 9	148.8	-215 2	11 2 - 12 0
FBRAN1	7 3	13 5	0 0	65 3	0 37	2 1	17 6	4 0 - 10.6	0 74	-11 5	-162.3	1730.2	5.2 - 9 4
FBRAN2	16 6	14 3	1 6	68 1	0.36	11 1	18 5	13 1 - 20.1	0 77	-4 0	-183.1	1921.7	14 5 - 18 7
FBRAN3	3 8	3 6	0 2	13 4	0 33	2 5	4 5	2 9 - 4 7	0 76	-1 4	-48 0	496.1	3 3 - 4 3
FFOLI	7 3	6.6	0.4	32 1	0.00	6.6	2 4	5 3 - 9.3	0 59	-1.7	-124.2	1059.3	6 0 - 8 6
FTOTAL	127 5	181 0	9 9	975 9	0.98	15 9	378 9	120 2 - 134.8	0 99	-17 9	619 4	4068 9	122.7 - 132 3
FDEAD	1 9	4 3	0.1	19 8	0.87	-0.6	8 5	1 4 - 2 3	0.86	-0 3	30 3	-42.8	1.4 - 2 4

NOTE. D - Diameter at breast height in metres
H - Height in metres
V - Volume inside bark in cubic metres

BRITISH COLUMBIA TREE BIOMASS REGRESSION ANALYSIS

20 TREMBLING ASPEN
(40 TREES)

	DBH(cm)	HEIGHT(m)	AGE(yrs)
MAXIMUM	34.8	25.6	92
MEAN	17.7	15.7	44
MEDIAN	17.4	15.8	46
MINIMUM	6.0	5.4	7

COM-PONENT	MEAN	S.D.	MIN.	MAX.	y = a + bDDH			95% CONFIDENCE INTERVAL FOR THE MEAN	y = a + bV + cDD				95% CONFIDENCE INTERVAL FOR THE MEAN
					RSQ	a	b		RSQ	a	b	c	
DWOOD	98.0	92.7	2.1	348.8	0.98	0.2	137.7	93.7 - 102.3	0.98	-4.8	358.4	573.5	93.6 - 102.4
DBARK	20.9	18.9	0.9	63.3	0.94	1.3	27.6	19.4 - 22.4	0.94	0.6	80.5	55.1	19.5 - 22.4
DBRAN1	5.5	8.2	0.0	38.2	0.42	-0.2	8.1	3.6 - 7.4	0.53	-3.3	-56.9	581.8	3.8 - 7.2
DBRAN2	12.3	18.8	0.2	117.6	0.26	1.7	15.1	7.3 - 17.4	0.27	-1.8	-42.2	634.3	7.4 - 17.3
DBRAN3	2.4	2.8	0.1	11.8	0.49	0.2	3.0	1.8 - 3.0	0.72	-1.2	-29.0	271.1	1.9 - 2.9
DFOLI	3.8	4.3	0.1	21.6	0.37	1.0	4.0	2.8 - 4.9	0.37	0.5	0.2	89.2	2.8 - 4.9
DTOTAL	143.0	134.4	5.1	483.3	0.94	4.1	195.5	132.5 - 153.5	0.94	-10.0	311.0	2209.0	132.8 - 153.2
FWOOD	172.6	161.5	4.4	611.9	0.99	1.4	241.1	167.1 - 178.2	0.99	-6.9	642.2	900.3	166.9 - 178.3
FBARK	39.2	33.7	1.9	109.1	0.92	4.7	48.5	36.2 - 42.1	0.92	4.1	163.8	-58.8	36.2 - 42.1
FBRAN1	9.2	13.3	0.0	63.8	0.41	0.0	13.0	6.1 - 12.4	0.52	-4.9	-90.8	930.2	6.4 - 12.1
FBRAN2	21.5	31.2	2.5	194.8	0.28	3.3	25.6	13.3 - 29.7	0.29	-2.6	-76.2	1110.0	13.3 - 29.6
FBRAN3	4.8	5.6	0.2	24.0	0.51	0.6	6.0	3.6 - 6.0	0.84	-2.7	-71.8	638.8	4.2 - 5.5
FFOLI	7.5	7.9	0.3	31.6	0.36	2.4	7.2	5.6 - 9.5	0.43	0.0	-43.5	467.7	5.7 - 9.4
FTOTAL	254.9	232.5	11.9	812.1	0.96	12.3	341.4	239.6 - 270.1	0.96	-13.0	923.6	3988.2	240.5 - 269.2
FDEAD	2.3	2.1	0.1	7.6	0.54	0.6	2.4	1.9 - 2.8	0.66	-0.2	-14.0	151.6	1.9 - 2.7

NOTE D - Diameter at breast height in metres
H - Height in metres
V - Volume inside bark in cubic metres

BRITISH COLUMBIA TREE BIOMASS REGRESSION ANALYSIS

21 WHITE BIRCH
(40 TREES)

	DBH(cm)	HEIGHT(m)	AGE(yrs)
MAXIMUM	30.6	22.7	142
MEAN	15.0	13.9	47
MEDIAN	14.4	13.6	34
MINIMUM	4.5	5.3	7

COM-PONENT	MEAN	S.D.	MIN.	MAX.	y = a + bDDH RSQ	a	b	95% CONFIDENCE INTERVAL FOR THE MEAN	y = a + bV + cDD RSQ	a	b	c	95% CONFIDENCE INTERVAL FOR THE MEAN
DWOOD	73.5	75.4	2.0	339.3	0.97	-2.7	171.5	69.3 - 77.6	0.96	-3.3	568.0	-135.8	69.1 - 77.9
DBARK	11.7	13.1	0.4	63.1	0.93	-1.2	29.1	10.6 - 12.8	0.92	-2.0	75.0	115.6	10.6 - 12.8
DBRAN1	3.5	5.3	0.0	25.8	0.67	-1.1	10.2	2.5 - 4.4	0.67	-2.0	4.2	184.6	2.5 - 4.4
DBRAN2	12.3	14.8	0.5	77.0	0.65	0.0	27.7	9.5 - 15.0	0.63	-0.6	77.9	67.9	9.5 - 15.0
DBRAN3	3.6	3.8	0.1	17.3	0.65	0.5	7.2	2.9 - 4.4	0.64	0.4	23.4	-3.0	2.9 - 4.4
DFOLI	5.1	4.3	0.2	14.9	0.61	1.6	7.8	4.3 - 5.9	0.61	1.0	6.9	119.3	4.3 - 5.9
DTOTAL	109.6	111.8	4.0	492.2	0.96	-2.9	253.5	102.8 - 116.5	0.96	-6.5	755.3	348.7	102.4 - 116.8
FWOOD	122.2	127.9	3.0	589.3	0.97	-7.2	291.4	115.4 - 129.0	0.97	-6.5	1022.0	-602.5	115.0 - 129.4
FBARK	21.3	23.4	0.9	96.0	0.88	-1.4	51.0	18.8 - 23.8	0.88	-2.4	141.6	137.4	18.7 - 23.8
FBRAN1	5.5	8.1	0.0	38.9	0.67	-1.4	15.5	4.1 - 7.0	0.68	-2.9	5.9	285.1	4.1 - 7.0
FBRAN2	19.9	24.0	0.7	126.4	0.65	0.0	44.9	15.5 - 24.4	0.63	-0.8	126.9	106.4	15.4 - 24.4
FBRAN3	6.5	7.2	0.1	35.1	0.53	1.1	12.2	5.0 - 8.0	0.52	1.4	53.6	-95.4	4.9 - 8.0
FFOLI	8.6	7.2	0.5	29.1	0.60	2.9	12.9	7.2 - 10.0	0.59	2.4	29.8	76.2	7.2 - 10.0
FTOTAL	184.1	188.7	6.6	822.9	0.96	-6.0	428.0	172.6 - 195.5	0.96	-8.8	1379.9	-92.8	172.0 - 196.1
FDEAD	0.7	1.3	0.1	5.4	0.00	0.5	0.4	0.3 - 1.1	0.00	0.3	-5.6	45.4	0.2 - 1.1

NOTE. D - Diameter at breast height in metres
H - Height in metres
V - Volume inside bark in cubic metres

BRITISH COLUMBIA TREE BIOMASS REGRESSION ANALYSIS

22 SHORE PINE
(40 TREES)

	DBH(cm)	HEIGHT(m)	AGE(yrs)
MAXIMUM	32.1	20.5	55
MEAN	15.9	12.3	36
MEDIAN	14.8	12.7	34
MINIMUM	7.1	5.8	10

COM-PONENT	MEAN	S.D.	MIN.	MAX.	y = a + bDDH RSQ	a	b	95% CONFIDENCE INTERVAL FOR THE MEAN	y = a + bV + cDD RSQ	a	b	c	95% CONFIDENCE INTERVAL FOR THE MEAN
DWOOD	62.7	64.9	5.7	292.7	0.99	4.7	137.0	61.0 - 64.4	0.99	2.3	426.1	-86.5	61.1 - 64.3
DBARK	6.8	6.0	0.7	24.4	0.87	1.8	11.9	6.1 - 7.5	0.87	0.9	20.6	98.1	6.2 - 7.5
DBRAN1	2.9	5.5	0.0	28.1	0.41	-0.3	7.6	1.6 - 4.2	0.62	-3.9	-63.8	556.5	1.9 - 3.9
DBRAN2	12.3	13.2	0.0	67.5	0.70	2.4	23.5	10.1 - 14.6	0.81	-4.5	-91.1	1038.0	10.6 - 14.1
DBRAN3	3.2	4.4	0.2	24.6	0.62	0.1	7.3	2.3 - 4.0	0.68	-1.8	-20.6	272.5	2.4 - 3.9
DFOLI	9.8	10.2	1.3	46.6	0.71	2.0	18.3	8.1 - 11.5	0.77	-2.0	-36.0	584.7	8.3 - 11.3
DTOTAL	97.7	98.2	10.5	431.3	0.98	10.7	205.7	93.0 - 102.4	0.98	-9.0	235.3	2463.4	93.9 - 101.5
FWOOD	128.4	130.9	12.6	587.4	0.99	11.6	276.0	124.3 - 132.5	0.99	6.1	844.3	-82.1	124.6 - 132.1
FBARK	14.2	11.5	1.8	51.6	0.91	4.4	23.3	13.2 - 15.3	0.91	3.4	59.8	67.4	13.2 - 15.3
FBRAN1	5.2	10.0	0.0	48.7	0.42	-0.7	14.0	2.9 - 7.6	0.63	-7.5	-119.7	1038.8	3.3 - 7.1
FBRAN2	24.5	24.6	1.6	123.2	0.71	5.8	44.3	20.5 - 28.6	0.86	-8.6	-203.6	2162.4	21.7 - 27.3
FBRAN3	6.6	8.8	0.4	49.0	0.64	0.3	15.0	5.0 - 8.3	0.71	-3.6	-43.8	570.3	5.2 - 8.1
FFOLI	20.8	21.3	2.6	94.6	0.70	4.8	38.0	17.2 - 24.5	0.76	-4.2	-91.7	1320.9	17.6 - 24.1
FTOTAL	199.9	196.1	21.8	860.9	0.98	26.1	410.5	190.3 - 209.4	0.98	-14.3	445.3	5077.8	192.4 - 207.3
FDEAD	7.1	9.9	0.5	43.8	0.91	-1.4	20.0	6.2 - 8.0	0.90	-2.1	52.6	48.7	6.1 - 8.1

NOTE: D - Diameter at breast height in metres
H - Height in metres
V - Volume inside bark in cubic metres

British Columbia
Standard Error of the Estimate for
Simple Linear Equations[a] (Oven-Dry Mass[b])

Species	Component						
	Wood	Bark	Branches (1)	Branches (2)	Branches (3)	Foliage	Total
Coastal Douglas-fir	35.65	9.36	19.73	7.47	3.27	10.08	48.75
Sitka spruce	13.51	2.73	5.00	5.54	3.44	8.64	19.64
Western red cedar	38.61	12.66	16.59	10.44	5.62	11.54	37.62
Interior Douglas-fir	132.95	28.70	34.48	24.82	15.04	15.55	163.05
Ponderosa pine	99.41	15.75	38.21	30.88	1.38	23.54	88.94
Western hemlock	32.88	14.26	10.90	9.29	5.07	8.60	59.75
White spruce	32.93	6.90	7.74	9.50	9.15	13.18	50.82
Englemann spruce	31.20	5.61	10.64	13.14	8.54	14.80	54.28
Pacific silver fir	10.20	1.96	3.22	4.22	1.85	7.13	17.56
Grand fir	38.09	12.75	5.73	8.42	4.11	16.94	47.65
Western larch	79.81	8.24	20.58	19.27	6.62	7.30	109.02
Western white pine	18.55	3.72	10.28	18.11	3.28	10.15	46.04
Lodgepole pine	37.67	3.53	4.19	9.10	2.74	7.21	44.13
Mountain hemlock	18.26	5.96	2.13	6.34	2.57	7.60	19.80
Black spruce	14.40	2.04	3.28	4.89	3.64	7.39	14.15
Subalpine fir	12.39	4.40	8.12	7.06	9.98	11.99	33.34
Yellow cedar	31.68	3.37	2.64	4.44	0.88	5.39	29.88
Black cottonwood	16.80	4.55	3.30	9.41	1.16	3.93	23.36
Red alder	3.47	1.05	3.98	4.06	0.82	1.66	9.32
Trembling aspen	14.12	4.66	5.61	16.07	1.51	3.42	33.00
White birch	14.20	3.67	3.05	8.96	2.31	2.67	23.23
Shore pine	5.11	2.14	3.38	5.74	2.48	4.92	12.24

[a] $B = b_0 + b_1 D^2 H$

[b] Rounded to the nearest 0.01 kg.

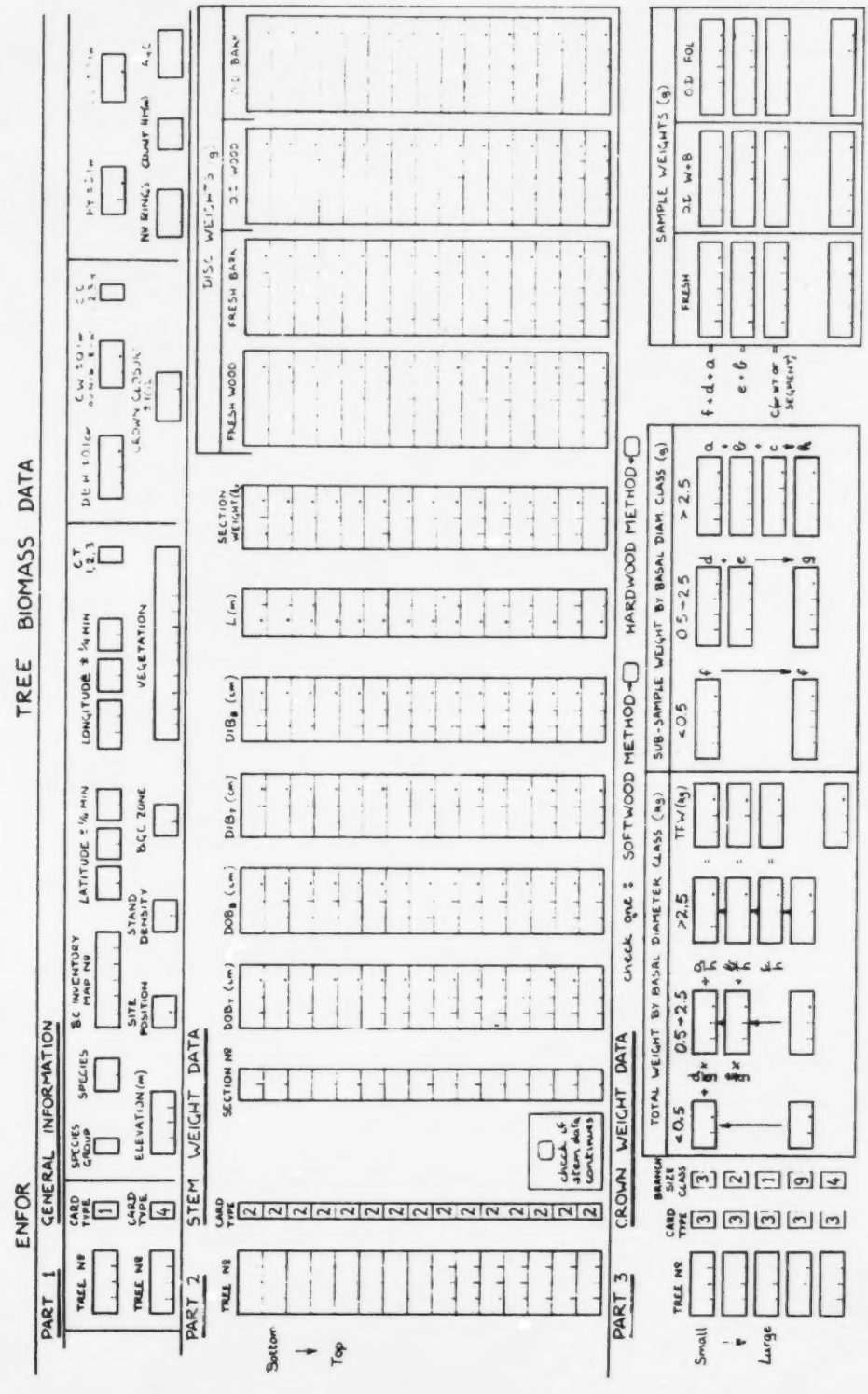
Standard Error of the Estimate for
Multiple Linear Equations (Oven-Dry Mass[a])

Species	Biomass Component						
	Wood	Bark	Branches (1)	Branches (2)	Branches (3)	Foliage	Total
Coastal Douglas-fir	39.21	10.13	21.80	11.26	4.94	16.46	69.27
Sikta spruce	15.72	2.95	6.67	10.85	4.86	18.86	30.02
Western red cedar	51.44	13.64	25.96	13.53	6.54	18.08	53.18
Interior Douglas-fir	140.92	30.13	34.06	30.45	18.87	23.59	191.13
Ponderosa pine	138.33	16.30	46.15	39.27	1.37	26.58	91.99
Western hemlock	40.92	19.06	16.33	14.08	9.74	14.62	88.95
White spruce	35.19	7.53	9.76	15.41	11.62	17.37	67.87
Engelmann spruce	33.59	6.02	11.96	15.39	10.76	16.47	57.35
Pacific silver fir	12.29	1.99	3.19	5.80	2.27	10.43	18.24
Grand fir	38.09	12.75	5.73	8.43	4.11	16.94	47.65
Western larch	100.80	8.27	25.16	25.82	10.02	9.01	150.61
Western white pine	18.53	3.92	12.03	20.24	3.42	13.02	53.04
Lodgepole pine	44.98	4.28	5.22	12.15	3.25	9.72	62.58
Mountain hemlock	21.52	8.11	3.56	6.75	2.69	8.96	18.59
Black spruce	17.97	2.09	3.83	6.66	4.62	9.95	17.94
Subalpine fir	13.58	4.52	11.64	11.10	11.73	15.92	45.48
Yellow cedar	31.15	3.53	2.76	4.97	1.18	6.04	27.80
Black cottonwood	19.87	4.73	3.29	12.03	1.25	3.98	23.52
Red alder	5.15	1.42	6.18	6.51	1.34	2.78	11.86
Trembling aspen	13.92	4.71	6.27	16.16	2.02	3.40	34.00
White birch	13.46	3.50	3.06	8.79	2.28	2.68	22.08
Shore pine	5.58	2.18	4.20	7.29	2.69	5.46	15.05

[a] Rounded to the nearest 0.01 kg.

Appendix B

Sample data form



Appendix C

The following field, laboratory and recording procedures were employed in this study:

I. Sample trees were selected according to the criteria established in discussion with the scientific authority and B.C. Ministry of Forests.

Basic tree data were recorded on the sample form as follows:

1) Tree number: each tree is assigned a unique number
2) Card type: 1
3) SP GRP: Species group, coded as:
   Hardwood 1
   Softwood 2
4) SP: Species; coded as:

Douglas fir - coastal	01
Sitka spruce	02
Western red cedar	03
Douglas fir - interior	04
Ponderosa pine	05
Western hemlock	06
White spruce	07
Engelmann spruce	08
Pacific silver fir	09
Grand fir	10
Western larch	11
Western white pine	12
Lodgepole pine	13
Mountain hemlock	14
Black spruce	15
Subalpine fir	16
Yellow cedar	17
Black cottonwood	18
Red alder	19
Trembling aspen	20
White birch	21

5) MAP NO: B.C.M.F. Inventory Sheet No.
6) LAT: latitude (D.M.S.)
7) LONG: longitude (D.M.S.)
8) DBH: diameter breast height (1.3 m) in cm to nearest 0.1 cm.
9) HT: total tree height (m) to nearest 0.1 cm.
10) CW: average crown width (m) to nearest 0.1 cm.
11) CL: crown length (m) to nearest 0.1 cm.
12) CT: cover type, coded as:
   pure (0-25% other species)
   mixed (25-75% other species)
   mixed (75-99% other species)
13) CC: crown class, coded as:

dominant	1
co-dominant	2
intermediate	3
suppressed	4

II. Stem data[1]

After each sample tree was selected, felled and delimbed, sample sections were cut from the stem at intervals of 2.0 m, starting at the base. The fresh weight of each stem section was obtained as below:

A. *Sections with > 30 cm diameter small end:*

1. Volume was calculated by Smalian's Formula (*ib* and *ob*):

$$V = h\,(Ab + Au)/2$$

2. A sample disc was cut from the small end of the section. In extremely large pieces, a wedge was taken from this. Green weight of this disc or segment was taken following removal of bark. The weight of bark was taken. Volume of the disc or segment, and bark was determined as per TAPPI standard T18m-53. The green weight/volume ratio was applied to the whole section (with bark and without bark) and recorded as follows:

B. *Sections with < 30-cm diameter small end:*

Weights of sections were taken directly. A sample disc was cut from the small end of the section.

---

[1] Stem is 0.3 cm above ground to a 2.5-cm top diameter (o.b.)

C. *General*

Fresh weights of wood and bark for each disc or segment were determined at a field lab within 24 hrs of cutting. Each disc was identified by tree number and disc number and, at the end of each week, all discs were brought to the main lab for drying and subsequent weighing. All green weight data for stem sections and discs was recorded as in (V).

III. Crown Data

Softwoods

The proportions of foliage, wood and bark in a softwood branch vary with the species and with the size and relative position of the branch, as well as site and stand conditions. This variation is a source of potential bias in the estimation of crown dry weights, in view of: 1) the need for some kind of subsampling system, 2) the low precision associated with small sample sizes, and 3) the practical difficulties involved in constructing efficient, unbiased sampling frames for crown weight estimation. The crown sampling methods used in this study attempted to reduce bias by taking branch size into account.

All live branches were sorted into three groups: 1) those with basal diameter (d) greater than 2.5 cm (measured 3 cm from the base of the branch), 2) those with basal diameter 0.5-2.5 cm, 3) those with basal diameter less than 0.5 cm. The total green weight of each of group was taken and recorded as indicated below. The total weight of dead branches (all sizes) was also taken and recorded.

In addition, six sample branches were randomly selected from each tree to provide data for estimation of dry crown component weights. These branches were flagged prior to delimbing. Two branches were selected from each of three size classes referred to earlier. The fresh weight of each of the sample branches were obtained in the field and the sample branches were bagged, labelled and brought in to the main lab for drying.

Hardwoods

Hardwood crowns were cut into sections less than 2 m long and then sorted into the following size classes according to the mid-diameter of the section: <2 cm (including all foliage), 2-6 cm, 6-10 cm and >10 cm.

The total weight of material in each of these size classes was obtained in the field laboratory and recorded as in (VI).

Two branches were randomly selected from each size class for estimation of the proportions of foliage and moisture. These samples were weighed in the field and brought back to the main lab for drying. For each size class only the total weight of the sample was recorded.

IV. Lab Methods

All disc and branch samples were transported to the main lab and dried in ovens at 105°C for at least 24 hrs. Some of the larger discs required up to 45 hrs depending on the size of the disc and the type of oven (convection vs. fan-driven types).

Dry weights of stem disc samples were recorded. Softwood foliage was separated from twigs after drying, either by hand or with winnowing machine fitted with screens of appropriate size, and then weighed separately. Dry softwood branch and foliage weight data were recorded.

Foliage of hardwood branch samples was separated by hand after drying and then weighed. The total dry weight of foliage and branch was recorded.

V. Recording Stem Weight Data:

Each line (card) corresponds to one disc or section.

1) TREE NO: repeat for each disc/section
2) CARD TYPE: 2

3) D/S No.: disc/section no.
4) SECTION WEIGHT: total fresh weight of section (kg) to nearest .1 kg. The space to the left was used for recording weights of pieces of section, and for any conversions, e.g.
   10 + 20 + 15 = 45 lbs = 20.4 kg
5) DISC WEIGHTS: fresh and dry weights of disc wood and bark (gm) to nearest .1 gm. Discs were taken at 2 m intervals, starting at ground level. Each disc was labelled by tree no. and disc. no. e.g.
   100-5 for disc 5 from tree 100.

VI Recording: Crown Weight Data:

One line (card) for each size class.

1) TREE NO.: repeat for each size class
2) CARD TYPE: 3
3) SIZE CLASS: size of branch

Softwoods	Code
>2.5 cm	1
0.5-2.5 cm	2
<0.5 cm	3
Dead	4

Hardwoods:	
>10 cm	1
6-10 cm	2
2-6 cm	3

4) TFW: Total fresh weight (kg) of material in a given size class, to nearest .1 kg. Use space to left of intermediate calculations and conversions.
5) SAMPLE WEIGHTS: Green and oven-dry sample weights were recorded as measured.

VII Weight Calculations:

Using the data recorded above, and the appropriately derived ratios for gw/odw, bark/wood, and foliage/wood, tree component weights are to be calculated and recorded.

Appendix D

The 22 tree species and varieties selected for sampling are listed below:

Coastal Douglas-fir	*Pseudotsuga menziesii* (Mirb.) Franco
Sitka spruce	*Picea sitchensis* (Bong.) Carr
Western red cedar	*Thuja plicata* Donn
Interior Douglas-fir	*Pseudotsuga menziesii* (Mirb.) Franco var. *glauca* (Beissn.) Franco
Ponderosa pine	*Pinus ponderosa* Laws.
Western hemlock	*Tsuga heterophylla* (Raf.) Sarg.
White spruce	*Picea glauca* (Moench) Voss
Engelmann spruce	*Picea engelmannii* Parry
Pacific silver fir	*Abies amabilis* (Dougl.) Forbes
Grand fir	*Abies grandis* (Dougl.) Lindl.
Western larch	*Larix occidentalis* Nutt.
Western white pine	*Pinus monticola* Dougl.
Lodgepole pine	*Pinus contorta* Dougl. var. *latifolia* Engelm.
Mountain hemlock	*Tsuga mertensiana* (Bong.) Carr.
Black spruce	*Picea mariana* (Mill.) B.S.P.
Subalpine fir	*Abies lasiocarpa* (Hook.) Nutt.
Yellow cedar	*Chamaecyparis nootkatensis* (D. Don.) Spach
Black cottonwood	*Populus trichocarpa* Torr. & Gray
Red alder	*Alnus rubra* Bong.
Trembling aspen	*Populus tremuloides* Michx.
White birch	*Betula papyrifera* Marsh.
Shore pine	*Pinus contorta* Dougl. var. *contorta*